VOLUME XI. NUMBER 6

THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

EDITOR

C. A. CHANT
University of Toronto, Toronto

ASSOCIATE EDITORS

J. S. PLASKETT
Dominion Observatory
Ottawa

SIR FREDERIC STUPART
Director of the Meteorological
Service of Canada, Toronto

PUBLISHED MONTHLY

July-August, 1917

PRINTED FOR THE SOCIETY
TORONTO: 198 COLLEGE ST.
FOREIGN AGENTS: WILLIAM WESLEY & SON,
28 ESSEX ST., STRAND, LONDON.

THE JOURNAL

OF THE

ROYAL ASTRONOMICAL SOCIETY

OF CANADA

VOL. XI. JULY-AUGUST, 1917. No. 6

Is the Climate Changing? - - - *Sir Frederic Stupart* 197

Magnetic Results 1916 - - - - - *Otto Klotz* 208

Spectroscopic Binary Orbits of 40 Aurigæ, π Arietis, Boss 5096 - *R. K. Young* 213

Miscellaneous Radial Velocities - - - - - *R. K. Young* 217

The 150-foot Tower Telescope of the Mount Wilson Solar Observatory *Adriaan van Maanen* 223

Clock Synchronization - - - - - - *R. M. Stewart* 232

Meetings of the Society

At Toronto - - - - - - *W. E. W. J.* 236

At Ottawa - - - - - - *E. A. H.* 239

Notes from the Meteorological Service

Report of the Weather in Canada, April-May, 1917 *Sir F. S.* 246

Magnetic Observations, March-April, 1917 - *W. E. W. J.* 249

Earthquake Records at Toronto and Victoria, B.C., April-May, 1917 *J. Y.* 252

Astronomical Notes

A Memorial to Sir William and Lady Huggins 254

Notes, Royal Astronomical Society - - 256

Rotating Masses - - - - - 256

The Temperature of Space - - - *J. R. C.* 257

Notes and Queries

New Moon in January, 1 B.C. - - - 258

An Auroral Display, Beginning in the South - 258

Art and Astronomy in Hamilton - - 259

Comets in the Sky - - - - *C. A. C.* 259

Upon request, made previous to publication of article, Contributors will be supplied with 50 Reprints in covers free; above that number will be charged at actual cost.

Editorial communications should be addressed to C. A. Chant, University of Toronto, Toronto, Ont.

Business correspondence, remittances, etc., should be addressed to Chas. P. Sparling, Treasurer of the Society, 198 College Street, Toronto.

Communications regarding Library matters should be addressed to the Librarian.

$2.00 per annum. Single numbers, 25 cents.

Subscription to the *Journal* is included in membership fee.

Anyone wishing to purchase a telescope may correspond with the Secretary, Toronto.

THE JOURNAL
OF THE
ROYAL ASTRONOMICAL SOCIETY
OF CANADA

VOL. XI. JULY-AUGUST, 1917. No. 6

IS THE CLIMATE CHANGING?

BY SIR FREDERIC STUPART

THE geologist has shown that through the long ages during which the earth has existed with a solid crust there have been large variations in its temperature and the distribution of its climatic zones. First it became evident that glaciation had prevailed over large areas now free from permanent snow—then followed the conclusion that there had been not only one, but several glacial periods, interrupted by periods of milder conditions, and indeed by conditions even milder than exist in the corresponding regions to-day. It is now admitted by all geologists that the climate of the earth has pulsated between glaciation which reached within 30 degrees of the equator, and milder conditions which are indicated by fossil remains in high latitudes, which can only be accounted for by supposing a temperate climate to have at one time existed in lands where is now a climate of arctic severity. There have been various hypotheses advanced to account for these climatic changes, but nothing conclusive is yet known. The astronomical theory as suggested by Croll appears inadequate to the meteorologist, particularly as it is based on cycles which recur with regularity, whereas the glacial periods

do not accord with this. The carbonic acid gas theory of Arrhenius and Chamberlin is unconfirmed by the geologist and finds but little favor with the meteorologist, many of whom are inclined to the hypothesis that climatic variations result from changes in atmospheric circulation due to a varying solar activity.

The purpose of this paper is to show what indications there may be, if any, that the climate of Canada is gradually changing; whether there is a tendency towards greater warmth or greater cold, or whether the rainfall is increasing or decreasing. Before proceeding, however, I would draw your attention to certain conclusions by recent writers regarding the climate of the past 3,000 years.

Many geographers and geologists have thought that there is strong evidence of progressive desiccation in Asia and lands near the Mediterranean, while on the other hand others have concluded that in Asia Minor at least there has been no change since the beginning of biblical history.

One of the arguments in favor of stability of climate first used by the Danish botanist and meteorologist Schouw, is as follows: In order that dates shall come to maturity, the mean annual temperature must be at least 69°. On the other hand, the vine cannot be profitably cultivated when the mean annual temperature exceeds 72°, since a higher temperature prevents the yield of fruits suitable for the manufacture of wine; thus the lower thermometric limit for the date differs very little from the upper thermometric limit of the vine. It can be shown that the palm and vine grew together in Palestine in the days of early biblical history, and they both grow in the same district to-day, hence it may be affirmed that the mean temperature of Palestine in the days of Moses was about the same as it is now. That the rainfall of Palestine has not changed in 2000 years receives confirmation from some measures of rainfall recorded in the Mishnah (a collection of early religious writings), measures which are closely in accord with modern results now obtained in Jerusalem.

In the *Geographical Journal* for June, 1904, Prince Kropotkin published an article entitled "The desiccation of Eurasia" in which he maintained that the climate of Eurasia is undergoing, since the end of the Glacial period, a steady progress towards drought, though there may be fluctuations in the advance." In a subsequent letter he submits that—"In regions that are desiccating after the thawing of the ice cap, desiccation in its later phases progresses relatively more rapidly on the higher level plateau than in the lowlands near the sea coast. It is retarded in the latter by the water supplied from the higher levels." He is willing tentatively to allow that within historic times, progressive desiccation in the lowlands near the sea may have been inappreciable.

These deductions by Prince Kropotkin are not concilient with those of the French Astronomer Arago, who already in 1838 had paid much attention to the subject, collecting all available historical records and had concluded "that 3,300 years have not brought any appreciable alteration in the climate of Southern Europe.

Upon this question Professor J. W. Gregory, F.R.S., of the University of Glasgow, who contributed a most valuable paper to the R.G. Society, December 8, 1913, expresses the opinion that evidence does not warrant the conclusion that desiccation is in progress. In his article he says—"Owing to the varied nature of the evidence to be considered, the extensive and scattered literature whence much of that evidence has to be gleaned, and the contradictory opinions expressed by high authorities, the problem whether the earth is drying up is hedged about with difficulties. But one fact does seem to me to result clearly from the evidence; there have been many widespread climatic changes in late geologic times, while in historic times there has been no world-wide change in climate."

Dr. Hildebrandsson, late Director of the Meteorological Service of Sweden, in a paper presented to the Royal Society of Sciences of Upsala, November 5th, 1915, gives the results of

investigations as to the dates of the opening of Baltic ports since the beginning of the 16th Century and concludes that the arrival of the springtime there has been constant through this long period. He further states that a study of the Icelandic reports leads to the belief that the climate of Iceland has not changed in the past thousand years, and his final conclusion is — "Our researches have led to the result that there exist everywhere climatic variations of long and short duration, but it is not possible to prove that the climate of Europe has changed for either better or worse during historic times."

Professor Ellsworth Huntington has been the exponent of the view that within the historic period, climatic changes have been pulsatory with a probable, but by no means certain, trend towards desiccation. In "The Climatic Factor" edited by Dr. Huntington, and published by the Carnegie Institution, is given a detailed account of an investigation by Professor A. E. Douglass, who during the years 1911 and 1912 measured the thickness of the rings of growth on the stumps of sequoia trees which varied from 250 to 3250 years of age. Professor Douglass claims "that the thickness of the annual rings of trees furnishes a reliable indication of variations in the water supply from year to year, and that while it is difficult to determine whether the climate at the beginning and end of a tree's life was the same, it is easy to determine whether there have been pulsations while the tree was making its growth. If trees from various parts of a given district form thick rings for a century and then thin ones for a long period, followed again by thick ones, we may be almost sure that the tree has lived through a period of unfavorable climate." Dr. Huntington states that the rainfall curve obtained from tree growth in California resembles that obtained from historical records of countries near the Mediterranean, and both indicate, not only that climatic pulsations have taken place, but that as we go backward through the centuries they become more pronounced.

In an article entitled "The Shifting of Climatic Zones in

Mexico," Professor Huntington has shown that the ruins of Maya civilization in Yucatan appear to indicate that the climate of that region has changed in a direction inverse to the changes that have apparently taken place in New Mexico and Arizona, and he elaborates the hypothesis that the climatic pulsations shown by changes in the growth of the big trees and many other indications are due to an alternate equatorward and poleward shifting of the earth's climatic zones.

Very valuable papers on the cyclical changes in latitude of the anticyclonic belts in both southern and northern hemispheres were contributed to the Royal Meteorological Society in April, 1908 and May, 1910, by Colonel H. E. Rawson, C.B.R.E., and the conclusions reached were closely in accord with those suggested by Dr. Huntington regarding the shifting of the climatic zones.

It is evident then, that while the question of climatic changes during the past 3000 years has not been definitely settled, enough has been done to show that if there be a general tendency towards desiccation or the reverse, or towards greater heat or greater cold, the change has been exceedingly slow and is largely masked by changes of fairly wide amplitude in both directions which occur at varying intervals.

Before considering the Canadian records it will, perhaps, be well to consider the various factors which we are convinced play the most important role in producing the distinctive characteristics of the earth's climatic zones, and also consider some few factors which may, but are not clearly proven, to affect climate.

These factors are as follows:

1. Distance from the equator.
2. Geographical position in relation to land and sea.
3. Altitude.
4. The prevailing winds, the outcome of the general atmospheric circulation; also the great ocean currents which are largely concomitant with atmospheric movement.

In considering periods embracing thousands of years, we may believe all these factors may have been operative to an

appreciable degree, but in relatively short term periods it would appear that No. 4 alone can have been operative, unless deforestation or drainage or other activities of man can be shown to have had some small effect.

When Champlain first landed in America, the territories west of the Great Lakes and the Mississippi were then, as to-day, mostly prairie land, while to the eastward the continent was an almost unbroken forest. As time went on, particularly in the United States, the forests gave place to cleared and cultivated lands, and in considering the question of changing climate in Canada some consideration must be given to the probable effect of this deforestation on temperature and rainfall. It would appear probable that lands when cleared absorb more solar heat in the warmer months than when forested, and that in the colder months radiation from the ground would be more unchecked; hence a tendency towards slightly warmer summers and colder winters, and such conditions would be likely to extend into Ontario, situated as it is towards the northern margin of deforested areas. As regards rainfall, it may be surmised that the effect of deforestation if anywhere appreciable would be most marked in areas remote from the seas which supply most of the moisture precipitated. Drainage of land may conceivably have some small effect on both temperature and precipitation, but apart from forest effect, it would seem to be of a local character.

The earliest Canadian climatic records are contained in "The Relations of the Jesuits," and as a preliminary study every reference to the climate and weather contained in the "Relations" has been abstracted and placed under various headings for consideration. Only very general conclusions can, however, be drawn as there were no instrumental records, and these to the effect that the missionaries described a climate almost identical with that which exists now. The winters were generally cold, but at times comparatively mild; the dates of the setting in and ending of winter have not changed and the depth of snow and thickness of ice as described correspond well with the systematic observations of the present time. The great heat and drought

experienced in some summers are, perhaps, the features most emphasized, and curiously enough there are several references to bush fires, and there is a statement that the air is almost always brown with smoke for a month or two in the summer. We can only conclude that the climate of Quebec in the 17th century was much as it is now.

During the 18th century and early part of the 19th, there are numerous historical records of abnormal seasons and periods of abnormal seasons in the United States, and the most noteworthy of these periods occurred between 1811 and 1816, with a series of remarkably cold summers. The summers of 1812 and 1816 were the coldest. In the former, from May to September, each month at Cambridge, Mass., was from 3°·6 to 7°·2 below average, and in the latter summer June and July were respectively 5° and 5°·8 below normal. In the Northern States, frosts are said to have occurred in every month of both summers.

It was not until the middle of the 18th century that any systematic records were kept at any one place in America and even up to the sixties in the nineteenth century there were few regular observers. The longest record in America appears to be that of Charleston, S.C., which with several breaks goes back to 1738, both for temperature and rainfall. At Cambridge, the record is from 1780 and at Philadelphia, temperature from 1748. A record which I consider as most valuable, is that at St. Paul, Minnesota, which for temperature dates from October, 1819, and for precipitation from 1827. This record is particularly valuable on account of St. Paul's situation in the northwest, only 400 miles from Winnipeg. It enables us to form a fair idea of the temperature of Manitoba during nearly 100 years, and the rainfall for 80 years.

The Toronto Observatory records began in 1840, but observations taken by Rev. Dr. Dade, a master of Upper Canada Col-College, takes it back to 1831.

In order to indicate, as plainly as possible, the changes during the period of instrumental records, the whole observing

period has in each case been divided into decades, and the mean values for these decades are given in the tables.

In the Toronto record, the precipitation figures give some ground for suspicion that the annual rainfall has diminished somewhat, but they are not conclusive, as a comparatively light summer rainfall in 1870 to 1899, was preceded and followed by heavier rains, and the figures in the snowfall column show that the winter snowfall in the forties was less than during the past sixteen years.

In temperature, there has been a manifest tendency towards higher mean annual and mean spring and summer temperature during the past twenty odd years, while any upward winter tendency is less noticeable. Another change which appears to be real is as regards late spring frost. In the early days of the Observatory, these frosts seem to have occurred later and been more severe than in later years, and certainly the official figures conform very exactly with the reports of early settlers.

The Montreal record apparently gives no indication whatever of change.

The Winnipeg and St. Paul tables may well be considered together. The record at the former place began in 1872, and the table shows a milder average winter during the past 17 years than the first three decades. Turning, however, to the St. Paul table it will be seen that the winters in the thirties and forties were much milder than any since, and it is almost certain that had we the Winnipeg record for these same years, corresponding conditions would be found, and the natural inference is that our tables show a climatic pulsation and no permanent change. The precipitation figures are equally indicative of no permanent tendency towards change in either direction since 1840.

The Edmonton record is too short for any definite conclusions, but the cold winters of the eighties are clearly shown, while the summer figures indicate that the summers have certainly not deteriorated. As regards precipitation, there are evidences that 1897 ended a comparatively dry cycle, since when the summer rains have been more ample.

The dates and degree of late spring and early autumn frosts in the western provinces are not quite conclusive, but the general inference from the longer records combined with those of short period, is that there has been no appreciable change since the early days of settlement. In eastern Canada, however, it may be that the diminishing liability to frost in the warmer months results from deforestation, but the question is one that must be investigated further.

The table showing precipitation at certain stations in the United States shows very clearly that deforestation does not play the important role that it was once thought to in diminishing rainfall, although there may be some ground for suspicion that in the northern middle States there may have been a slight diminution.

Toronto

Table showing mean values for precipitation and temperatures during the several decades that observations have been taken.

Period	Precipitation			Temperature					
	Annual	Summer Rain	Winter Snowfall	Annual	Winter	Spring	Summer	June Minimum	Agincourt
1830- 9					24·1		65·7		
40- 9		13·10	56·6	44·3	25·5	47·1	64·4	35·8	
50- 9	35·1	12·66	65·5	44·0	23·9	45·7	65·6	37·1	
60- 9	33·3	11·83	73·3	44·1	23·4	46·1	65·1	40·4	
70- 9	32·6	10·02	84·9	44·2	22·8	47·0	66·5	41·6	
80- 9	30·1	10·57	62·6	44·0	23·1	46·9	65·4	41·4	
90- 9	31·7	10·72	54·5	45·4	24·9	48·2	66·6	43·3	
1900- 9	31·5	11·94	59·2	46·0	23·4	47·9	66·7	47·4	40·0
10-16	31·0	11·06	61·4	46·7	24·9	50·0	67·2	40·3	37·1

The period of greatest summer drought occurred in the seventies, '73 to '77, --the next in the nineties, especially '95, '96, '98 and '99,--and the third in the tens of which '11, '13, '14 and '16 were the most pronounced.

Montreal, Que.

Period	Precipitation			Temperature				
	Annual	Summer Rain	Winter Snow	Annual	Winter	Spring	Summer	June Minimum
1863- 9	38·71	9·52	72·5	42·4	16·3	46·7	67·3	
70- 9	37·95	9 81	71·8	43·1	16·7	48·5	68 6	46·4
80- 9	41·28	10·40	80·9	41·4	15·3	46·5	66·2	44·9
90- 9	40·33	12·60	74·4	42·5	16·1	47·9	66·7	46·3
1900- 9	42·70	10·51	90·8	42·2	16·1	47·5	66·6	44·5
10-16	37·91	8·58	71·5	43·2	16·5	49·7	67·0	43·7

The lightest rainfalls during the summer months occurred iu the years 1864, 1868, 1881, 1887 and 1913, while the heaviest falls occurred in 1866, 1869, 1882, 1892, 1893, 1896 and 1900.

Winnipeg, Man.

Period	Precipitation			Temperature					
	Annual	Summer Rain	Winter Snow	Annual	Winter	Spring	Summer	Date 1st Frost	Degree
	Ins.	Ins.	Ins.	°	°	°	°		°
1872- 9	24·63	14·40	54·4	33·4	0 3	43·7	65·0	Sept. 5	30·9
80- 9	19·82	9·40	57·9	32·2	- 5·0	43·3	63·8	Sept. 7	29·7
90- 9	21·63	10·85	52 7	33·8	0·7	44·5	63·7	Sept. 6	32·0
1900- 9	20·65	11·59	52·2	36·2	4·2	45·4	64·0	Sept. 13	31·0
10-16	19·96	10·45	44·8	37·0	5·1	47·1	64·3	Sept. 10	30·9

St. Paul, Minnesota

Period	Precipitation		Temperature		
	Annual	Summer Rain	Winter	Spring	Summer
1820- 9			14·7	53·5	72·4
30- 9			17·3	54·4	70·9
40- 9	27·15	14·47	17·2	51·5	68·2
50- 9	24·77	12·11	13·4	51·1	70·7
60- 9	29·27	14·87	14·6	50·8	69·3
70- 9	29·94	17·04	15·7	52·1	70·2
80- 9	26·18	12·64	13·9	52·4	69·9
90- 9	27·19	13·95	16·0	51·5	69·6
1900- 9	31·37	17·24	16·2	51·6	69·2
10-16	25·21	13·62	15·2	53·3	69·8

The Summers of partial drought occurred in 1839, 1841, 1852, 1864, 1882, 1886, 1893 and 1894, and Summers of complete drought in 1856, 1863 and 1916.

The two coldest Winter decades were in the fifties and eighties. The thirties and forties were the warmest.

EDMONTON, ALTA.

Period	Precipitation		Temperature					
	Annual	Summer Rain	Annual	Winter	Spring	Summer	Date of 1st Frost	Degree
1883-9	12·88	6·40	34·9	5·8	38·6	58·1	Aug. 30	30·4
90-9	16·70	8·79	36·4	10·6	37·3	59·7	Sept. 4	31·4
1900-9	19·39	9·89	37·3	12·7	38·5	59·0	Sept. 2	31·0
10-5	19·88	11·95	37·9	11·1	41·4	59·3	Aug. 30	32·0

AVERAGE PRECIPITATION, BY DECADES, AT CERTAIN UNITED STATES STATIONS

Period	Rochester, N.Y.	New Bedford Mass.	Albany N.Y.	New York N.Y.	Philadelphia Pa.	Cincinnati Ohio	Marietta Ohio	Period	Charleston, S.C.
1810-9		41·96						1738-65	47·50
20-9		49·62			39·37		42·79	85-91	50·43
30-9	29·03	47·47	40·64	45·94	42·17		40·60	1807-11	48·70
40-9	32·49	43·03	41·73	36·60	44·54	40·26	42·09	32-41	52·13
50-9	33·08	47·06	38·78	39·40	44·10	43·69	43·89	42-51	40·30
60-9	35·85	45·52	37·21	41·63	49·37	39·81	44·18	52-61	44·00
70-9	37·66	47·58	42·96	46·83	43·75	39·80	39·45	62-71	51·30
80-9	31·65	46·53	37·32	43·12	39·53	41·16	44·50	72-81	60·70
90-9	34·40	49·57	35·81	40·18	37·93	37·00	41·06	82-91	51·20
1900-9	31·09	40·33	32·34	44·38	43·52	33·61	40·62	92-01	49·60
10-5	31·51	42·60	31·08	40·20	44·88	39·05	39·87	1902-11	36·96
								12-15	45·92

Rochester, N.Y.—Note the thirties, driest period.

METEOROLOGICAL OFFICE,
TORONTO, ONT.
June, 1917.

MAGNETIC RESULTS 1916

By Otto Klotz

THE field of operations during the season of 1916 was mostly in the wilds of Northern Ontario, which have recently been opened by railway, and some stations between lakes Manitoba and Winnipeg to fill in magnetic lacunæ.

Our data have now sufficiently accumulated and cover Canada from the Atlantic to the Pacific, nearly 500 stations altogether, so that for this part of Canada a fairly good magnetic map for a uniform epoch can be constructed, provided we obtain during the coming season an adequate number of observations at repeat stations for deducing the annual change necessary for reducing all the observations to a common epoch.

We have already quite a number of repeat stations, but some more are required to give us additional data to prepare the contemplated magnetic map.

All the observations during the past year have again been made by Mr. C. A. French, and the following is his account of the past season's work :

During the season of 1916 fifty-five stations were occupied, besides a second station at Sudbury. In addition, spring and fall observations were taken at Ottawa and at the Standard Magnetic Observatory at Agincourt.

The instruments used throughout the season were the half-seconds chronometer, Bond 511, and magnetometer No. 20, which was purchased from the Carnegie Institution, of Washington, D.C., in the spring of 1916. This type of magnetometer, known as the Universal type, is described in Vol. II., Researches of the Department Terrestrial Magnetism, pp. 7-9. The instrument is completely assembled in one unit, comprising astronomical telescope and magnetometer for determining time,

azimuth, declination and horizontal intensity, and a dip circle for the determination of inclination. Its compactness and portability makes it very suitable for field observing.

The results of the standardizing comparisons at Agincourt, and also at Washington, are as follows :

* I.M.S. — No. 20

Date	Declination	Horizontal Intensity	Remarks
1916	′	c.g.s.	
May	− 0·9	− ·000084	Determined at Agincourt
October	− 0·9	− ·000071	Determined at Agincourt
Mean	− 0·9	− ·000076 = − ·0004811	
1915			
March	− 0·7	− ·0002311	Determined at Washington

A series of dip comparisons was made between No. 20 and the Dominion Observatory earth inductor, Toepfer No. 1911, in the fall of 1916, the correction to the latter instrument on I.M.S. having been determined at Washington, in December, 1915. The results of the comparisons made at Ottawa, also the results of the comparisons made at Washington for determining the correction to No. 20, are given below.

I.M.S. — No. 20

Needle No. 1	Needle No. 2	Needle No. 5	Needle No. 6	Remarks
− 0′·7	− 0′·2	0′·0	1′·4	Determined at Washington
− 1′·5	− 1′·0	− 0′·4	1′·2	Determined at Ottawa

Below are given the results of observations taken during the season of 1916. The results have all been reduced to I. M. S. by applying to the observed values the corrections determined in 1916, namely, − 0′·9 for declination, − ·00048H for horizontal intensity and − 1′·5, − 1′·0, − 0′·4 and 1′·2 for inclination observed with needles No. 1, No. 2, No. 5 and No. 6, respectively.

* I.M.S. = International Magnetic Standard (JOURNAL ROYAL ASTRONOMICAL SOCIETY OF CANADA, May-June, 1916, p. 258).

Station	Latitude	Longitude	Date	Declination	Range of Decl.	Dip	Hor. Int.	Total Int.
	° ′	° ′		° ′	′	° ′	C.G.S.	C.G.S.
Ottawa	45 23·6	75 43·0	Apr. 20-29	13 28·6W.	14·5	75 40·8	·14900	·60484
Bolton	43 53·1	79 44·2	May 12, 13	6 42·0W.	12·1	74 48·5	·15956	·60889
Alliston	44 09·0	79 53·1	" 15-17	6 30·7W.	15·0	75 04·0	·15714	·60979
Craighurst	44 32·5	79 42·3	" 18, 19	7 27·0W.	14·4	75 27·4	·15319	·61005
Lovering	44 45·9	79 36·0	" 20, 22, 23	7 46·0W.	10·1	75 20·4	·15385	·60790
MacTier	45 08·7	79 46·2	" 24, 25	7 13·4W.	12·4	75 47·0	·14962	·60923
Parry Sound	45 21·6	80 02·0	" 26, 27	7 53·2W.	14·4	75 41·3	·15052	·60891
Byng Inlet	45 47·0	80 33·6	" 29	8 02·8W.	20·9	76 06·0	·14779	·61521
Burwash	46 19·2	80 47·2	" 31, June 1	7 37·5W.	17·6	76 35·4	·14222	·61324
Nairn	46 20·4	81 35·4	" 3	6 09·1W.	20·6	76 30·5	·14390	·61679
Massey	46 13·2	82 04·4	" 5, 6	5 45·4W.	14·0	76 26·2	·14435	·61551
Algoma	46 11·4	82 48·8	" 6-8	5 16·8W.	21·5	76 31·6	·14329	·61500
Thessalon	46 16·3	83 33·3	" 9, 10	4 20·0W.	13·2	76 32·2	·14361	·61082
Desbarats	46 21·3	83 55·5	" 12, 13	4 55·4W.	14·1	76 35·7	·14336	·61838
S. Ste. Marie	46 30·9	84 17·6	" 15-17	3 32·6W.	15·5	76 59·1	·13976	·62059
Searchmont	46 47·1	84 02·3	" 19-21	4 08·0W.	21·9	77 09·6	·13784	·62026
Pangis	47 08·2	84 16·3	" 21-23	4 12·2W.	14·2	77 11·0	·13740	·61939
Frater	47 20·4	84 33·2	" 24, 25	4 14·1W.	19·8	77 31·0	·13408	·62029
Agawa	47 40·3	84 30·5	" 27, 28	4 07·8W.	18·6	77 32·7	·13335	·61830
Tatnal	48 41·8	84 13·6	" 30	5 32·0W.	10·7	78 24·0	·12472	·62078
Hawk Jct.	48 05·7	84 33·2	July 1-3	4 47·4W.	20·9	77 58·1	·13000	·62364
*Sudbury (Station 1916)	46 30·9	81 01·5	" 5, 7	7 53·0W.	11·7	76 30·3	·14378	·61013
Sudbury (Station 1913)	46 30·9	81 01·5	" 6	7 46·1W.	11·6	76 33·6	·14328	·61645
Caipha	47 01·8	81 12·2	" 9	6 27·4W.	17·1	77 06·0	·13725	·61478
Kashbaw	47 25·3	81 31·8	" 11, 12	8 24·4W.	9·9	77 15·9	·13654	·61939
Gogama	47 40·3	81 42·9	" 13-15	7 24·8W.	15·5	77 30·8	·13351	·61750
Tionaga	48 05·7	82 07·4	" 16-18	5 53·4W.	17·2	78 01·8	·12904	·62218
Foleyet	48 15·1	82 23·6	" 18-20	7 18·4W.	19·7	78 10·0	·12689	·61878
Agate	48 32·0	82 57·9	" 21, 22	6 00·7W.	16·0	78 12·8	·12628	·61821
Fire River	48 46·4	83 36·5	" 26, 27	6 05·0W.	20·5	78 19·2	·12585	·62165
Oba	49 04·0	84 06·7	" 23-25	6 04·6W.	21·2	78 38·3	·12327	·62573
Hornepayne	49 13·7	84 47·2	" 28-29	4 31·3W.	19·0	78 51·8	·12095	·62620
Hillsport	49 27·4	85 33·4	"31 Aug. 1	3 53·0W.	21·0	79 13·8	·11623	·62199
Caramat	49 37·0	80 08·5	Aug. 3	5 05·2W.	16·5	78 24·2	·12618	·62770
Longuelac	49 47·4	86 33·1	" 4, 5	1 15·8W.	21·5	78 48·2	·12158	·62613
Bankfield	49 44·4	87 01·1	" 14, 15	2 21·3W.	24·2	80 11·4	·10555	·61949
Jellico	49 41·8	87 30·8	" 11-13	0 40·0W.	19·5	79 08·2	·11824	·62738
Beardmore	49 36·6	87 56·7	" 9, 10	1 47·6W.	16·9	78 46·0	·12246	·62863
Orient Bay	49 22·5	88 07·5	" 7	0 09·2E.	13·9	78 42·6	·12240	·62521
Twin City Jct.	48 22·3	89 24·4	" 16, 17	2 41·8E.	21·9	77 53·0	·13112	·62467
Ft. William	48 23·9	89 15·2	" 18	2 51·5E.	19·2	77 50·6	·13149	·62440
Mack	49 09·8	90 22·6	" 22, 23	4 27·0E.	26·0	78 07·7	·12932	·62862
Petry	49 20·5	90 50·7	" 24, 25	4 25·4E.	17·6	78 15·8	·12782	·62837
Tannin	49 39·2	91 00·2	" 26, 27	4 41·4E.	21·2	78 52·0	·12159	·62970
Hunt	49 53·4	91 27·8	" 29, 30	4 51·8E.	20·1	78 56·4	·12010	·62605
Graham	50 05·5	91 54·5	" 31	5 05·5E.	13·5	79 13·8	·11783	·63050
Winnipeg	49 51·9	97 10·0	Sept. 2, 4, 5, 6	13 35·2E.	13·4	78 10·4	·12929	·63083
Selkirk	50 09·3	96 53·1	" 7, 8	10 55·6E.	16·0	78 13·6	·12781	·62640
Gimli	50 38·3	97 00·5	" 9	11 52·3E.	16·2	78 30·0	·12564	·63019
Riverton	51 00·1	97 00·4	" 12, 13	11 49·1E.	13·4	79 01·4	·11959	·62807
Warren	50 08·2	97 32·9	" 15, 16	13 57·4E.	25·2	78 33·2	·12395	·62457
Oak Point	50 30·3	98 02·6	" 18	13 06·0E.	13·5	78 23·7	·12668	·62794
Mulvihill	50 58·5	98 11·2	" 19	13 03·4E.	11·7	78 41·2	·12296	·62679
Grahamdale	51 23·6	98 31·2	" 20	12 30·9E.	12·0	78 45·4	·12298	·63074
Gypsumville	51 46·5	98 36·5	" 21-23	12 40·4E.	12·3	78 49·1	·12246	·63150
Ste. Agathe	49 33·9	97 10·9	" 27, 28	11 43·8E.	8·0	77 31·0	·13599	·62913
Rosenfeld	49 12·3	97 32·5	" 29	11 42·2E.	9·2	77 15·6	·13862	·62859
Ottawa	45 23·6	75 43·0	Oct. 18-31	13 30·9W.	11·8	75 41·5	·14912	·60338

* As the suitability for future observations of the station selected in 1913 (Station 1913) seemed doubtful, a new station (1916) was selected.

Annual Change

Station	Date	*Obs.	Declination	Dip	Hor. Int.	Date	*Obs.	Declination	Dip	Hor. Int.	Aver. Annual Change		
											Dec.	Dip	Hor. Int.
			° ′	° ′	C.G.S.			° ′	° ′	C.G.S.	′	′	C.G.S.
a Ottawa	Oct. 1906	C.I.	12 44·4W.	75 39·1	·15222	Oct. 1916	D.O.	13 30·9 W.	75 41·5	·14912	- 4·6	0·2	- ·00031
b Agincourt	Oct. 1906	M.S.	5 48·4W.	74 36·1	·16391	Oct. 1916	D.O	6 34·4 W.	74 44·3	·15967	- 4·6	0·8	- ·00042
a Algoma	Oct. 1906	C.I.	4 35·4W.	76 24·0	·14668	June 1916	D.O.	5 16·8 W.	76 31·6	·14329	- 4·3	0·8	- ·00035
Sudbury	July 1913	D.O.	7 39·4W.	76 33·8	·14429	July 1916	D.O.	7 46·1 W.	76 33·6	·14328	- 2·2	- 0·1	- ·00034
Fort William	June 1910	D.O.	3 15·6 E.	77 49·4	·13326	Aug. 1916	D.O.	2 51·5 E.	77 56·6	·13149	- 4·0	0·2	- ·00029
Graham	Aug. 1914	D.O.	5 14·8 E.	79 13·8	·11835	Aug. 1916	D.O.	5 05·5 E.	79 13·8	·11782	- 4·6	- 0·1	- ·00026
a Winnipeg	Sept. 1906	C.I.	13 59·0 E.	78 07·4	·13167	Sept. 1916	D.O.	13 35·2 E.	78 10·4	·12929	- 2·4	0·3	- ·00024
c Oak Point	Sept. 1908	C.I.	13 35·3 E.	78 20·2	·12777	Sept. 1916	D.O.	13 06·0 E.	78 23·7	·12668	- 3·7	0·4	- ·00014

*C. I.—Carnegie Institution; M. S.—Meteorological Service; D. O.—Dominion Observatory.

a Values communicated in MS. by C. I.

b Values taken from the Journal of the Royal Astronomical Society of Canada.

c Values taken from "Researches of the Department of Terrestrial Magnetism."

A " - " sign under "Average Annual Change" of Declination indicates that western declination is increasing and eastern declination decreasing.

NOTE—If the change in the magnetic elements at any particular place is to be accurately determined it is necessary that all results should be reduced to a common standard. The Dominion Observatory (D.O.) results for declination and horizontal intensity have, since 1906, been reduced to the Agincourt Magnetic Observatory standard, the latter observatory being a branch of the Meteorological Service (M.S.) of Canada. This reduction has been made possible by making comparisons between instruments in the spring and fall of each year. The Meteorological Service has, however, recently adopted the International Magnetic Standard as their standard, having determined the corrections to their instruments to reduce them to standard. (JOURNAL ROYAL ASTRONOMICAL SOCIETY OF CANADA, May-June 1916, p. 258).

The M.S. and D.O. values of declination and horizontal intensity, for dates prior to 1916 and given in the above table, differ from values previously published for the corresponding dates and places by the amount of these corrections, namely, $-0'.9$ for declination and $.00033H$ for horizontal intensity, due to the reduction of the values to International Magnetic Standard (I.M.S.).

The standard for inclination prior to 1910 was the Dover dip circle No. 200 of the Agincourt Observatory. From comparisons made at Washington and Agincourt the correction to this instrument on I.M.S. was $0'.0$. (Vol. II., "Researches of the Department of Terrestrial Magnetism," p. 216, equation II., and JOURNAL OF THE ROYAL ASTRONOMICAL SOCIETY OF CANADA, May-June, 1916, p. 258). For 1911 and years following, the Toepfer earth inductor No. 1911, of the Dominion Observatory, was taken as the standard, but the correction to this instrument on I.M.S. was undetermined until December, 1915. The correction, which was determined at Washington, is $-0'.25$, and was used in the reduction of the values in the above table.

No corrections have been applied to the C.I. results used in the table, though these values were reduced to a provisional standard, ("Researches of the Department of Terrestrial Magnetism and Land Observations 1905-1910, p. 42) which differs slightly from the I.M.S. (Vol. II., "Researches of the Department of Terrestrial Magnetism," pp. 270-273). This introduces a small error in the C.I. value of each element, but, as the period between the first and second determination of the elements ranges from eight years to ten years, the resultant error in the annual change will be so small as to be negligible.

DOMINION OBSERVATORY,
OTTAWA, CANADA,
March 23, 1917.

SPECTROSCOPIC BINARY ORBITS OF 40 AURIGÆ, π ARIETIS, BOSS 5996

By Reynold K. Young.

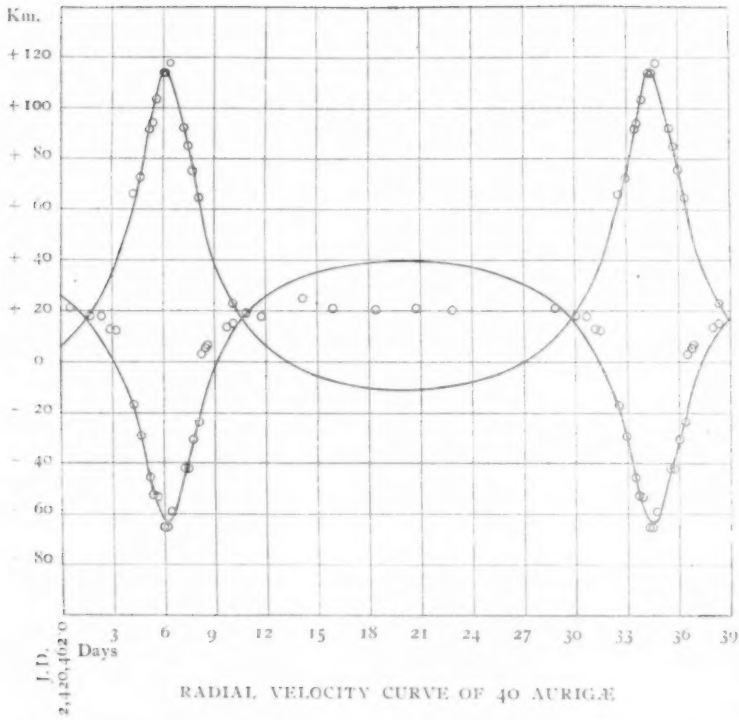
THE three orbits given below will appear in detail in the *Publications of the Dominion Observatory*. The elements are in each case the result of a least square solution. The orbit of 40 Aurigæ is derived from 53 one prism spectrograms, that of π Arietis from 50 and that of Boss 5996 from 40.

1. 40 Aurigæ

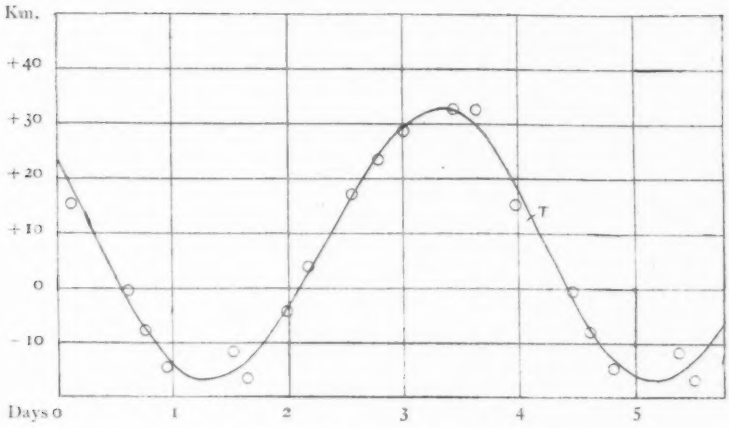
($\alpha = 5^h\,59^m{\cdot}6$, $\delta = +\,38°\,29'$, Mag. 5·31, type *A*).

P =	28·28 days	± ·005 days (est.)
T =	J.D. 2,420,468·197	± ·088 days.
e =	0·556	± ·0065
ω_1 =	178°·40	± 3°·1
ω_2 =	1°·60	± 3°·1
K_1 =	51·38 km.	± 1·50 km.
K_2 =	62·51 km.	± 1·64 km.
γ =	+ 16·91 km.	± 1·83 km.
$a_1 \sin i$ =	16,550,000 km.	
$a_2 \sin i$ =	20,140,000 km.	
$m_1 \sin^3 i$ =	1·354 × sun.	
$m_2 \sin^3 i$ =	1·113 × sun.	

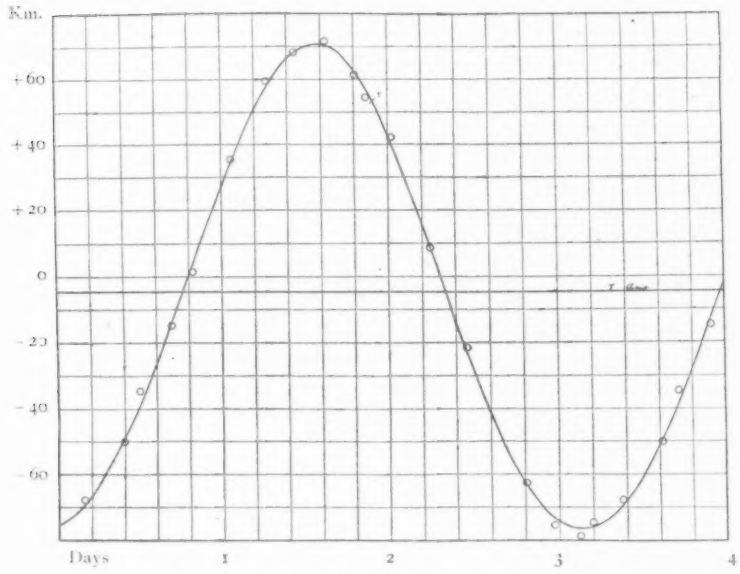
The probable error of a single velocity for primary is 2·3 km., for the secondary is 4·1 km. Only those spectrograms on which both components were visible were used in the solution. In spite of the small fraction of the period which is covered by these plates, the elements are fairly well determined.



RADIAL VELOCITY CURVE OF 40 AURIGÆ



RADIAL VELOCITY CURVE OF π ARIETIS



RADIAL VELOCITY CURVE OF BOSS 5996

2. π Arietis

($\alpha = 2^h\ 43^m{\cdot}7$, $\delta = +17°\ 3'$, Mag. 5·30, Type *B* 5).

$P = 3{\cdot}854$ days	$\pm$ ·002 days (est.)
$T =$ J.D. 2,420,370·259.	$\pm$ ·351 days.
$\omega = 78°{\cdot}27$	$\pm$ 21° 9
$e = 0{\cdot}042$	$\pm$ ·025
$K = 24{\cdot}77$ km.	$\pm$ ·70 km.
$\gamma = +7{\cdot}81$ km.	
$a \sin i = 1{,}310{,}000$ km.	
$\frac{m_1^3 \sin^3 i}{(m+m_1)^2} = {\cdot}0061 \times$ sun.	

The probable error of a single observation is 3·7 km. The values of e and ω are very uncertain

3. Boss 5996

($\alpha = 23^h\ 13^m{\cdot}7$, $\delta = +41°\ 13'$, Mag. 5·90, type *A*)

$P = 3{\cdot}2195$ days	
$T =$ J.D. 2,421,059·912	$\pm$ ·064 days
$\omega = 40°{\cdot}57$	$\pm$ 7°·13
$e = {\cdot}0365$	$\pm$ ·0067
$K = 73{\cdot}56$ km.	$\pm$ 0·45 km.
$\gamma = -4{\cdot}87$ km.	
$a \sin i = 3{,}240{,}000$ km.	
$\frac{m_1^3 \sin^3 i}{(m+m_1)^2} = {\cdot}133 \times$ sun.	

The probable error of a single plate is 2·5 km. The large value of K and the accordance of measures render the elements fairly determinate.

Dominion Observatory,
Ottawa, Canada.

MISCELLANEOUS RADIAL VELOCITIES

By Reynold K. Young

IN the course of the determination of the orbits of spectroscopic binary stars during the years 1913-17 the following miscellaneous velocities have been obtained. For the most part they are of stars for which a few plates were made to estimate the amount of labor necessary to compute an orbit and which were discarded because more favorable material presented itself.

γ Pegasi

($\alpha = 0^h\ 8^m{\cdot}1$, $\delta = +\ 14°\ 38'$, Mag. 2·87, type *B*2)

Plate	Date	G.M.T.	Observer	Velocity	No. of Lines	Range	Quality
	1913	h m					
5721	Sept. 30	15 30	Young	+ 5·3 km.	11	27 km.	good

This star was announced as binary from both the Lick and Yerkes Observatories. Lick Observatory *Bulletin*, 199, and *Astrophysical Journal*, Vol. XXXI., p. 431. The range is probably less than ten kilometers. The lines are of good quality.

τ Persei

($\alpha = 2^h\ 47^m{\cdot}2$, $\delta = +\ 53°\ 21'$, Mag. 4·06, type *G*0)

Plate	Date	G.M.T.	Observer	Velocity	No. of Lines	Range	Quality
	1916	h m					
7938	Dec. 14	20 22	Young	+ 1·6 km.	8	30	weak
7954	Dec. 19	14 23	"	+ 7·3 km.	13	25	good

Announced as binary, range + 10 to − 4. Lick Observatory *Bulletin*, No. 4.

δ Geminorum

($\alpha = 7^h\ 14^m{\cdot}2$, $\delta = +\ 22°\ 10'$, Mag. 3·51, type *F*)

Plate	Date	G.M.T.	Observer	Velocity	No. of Lines	Range	Quality
	1916	h m					
7807	Sept. 9	21 58	Young	− 3·3 km.	6	25	good
7827	Sept. 30	22 17	"	+ 17·4 km.	4	24	"
7840	Oct. 2	21 29	"	− 6·2 km.	5	25	"
7841	Oct. 2	22 01	"	+ 1·0 km.	6	56	"

Announced as binary, range + 21 to − 56, *A. N.* 195, p. 171. The lines in this spectrum are extremely poor.

β Canis Majoris

($\alpha = 6^h\ 18^m{\cdot}3$, $\delta = -\ 17°\ 54'$, Mag. 1·99, type *B*1)

Plate	Date	G.M.T.	Observer	Velocity	No. of Lines	Range	Quality
	1916	h m					
7936	Dec. 14	19 30	Young	+ 38·5	16	36	good
7937	" "	19 43	"	+ 34·1	12	19	good
7942	Dec. 16	17 32	"	+ 35·9	22	33	good
7943	" "	17 48	"	+ 36·0	23	39	good
7944	" "	18 02	"	+ 38·2	24	30	good
7945	" "	18 17	"	+ 37·2	22	43	good
7946	" "	18 41	"	+ 39·2	27	42	good
7951	Dec. 17	15 46	"	+ 25·4	23	30	good
7955	Dec. 19	15 16	"	+ 27·9	26	33	good
7956	" "	15 39	"	+ 31·3	10	30	fair
	1917						
7995	Jan. 16	13 40	"	+ 28·2	13	23	good
7997	" "	15 30	"	+ 19·9	11	41	good
8011	Jan. 22	17 07	"	+ 36·0	12	22	good
8012	" "	17 30	"	+ 36·5	13	25	good

An approximate orbit for this binary is published in Campbell's second catalogue of spectroscopic binaries. There are numerous oxygen lines in the spectrum and they and the helium, hydrogen and silicon lines are sharp and narrow, well suited for wave-length determination. It was chiefly for the identification of the oxygen lines that the above measures were made. In all, forty-three lines were measured and of these nineteen can be identified with the oxygen spectrum.

α CANCRI

($\alpha = 8^h\ 53^m{\cdot}0$, $\delta = +\ 12°\ 15'$, Mag. 4·27, type *A*5)

Plate	Date	G.M.T.	Observer	Velocity	No. of Lines	Range	Quality
	1913	h m					
5330	Jan. 28	16 30	H	− 10·8	13	25	good
5340	Feb. 3	18 50	C	− 3·2	12	25	good
5351	6	18 30	P′	− 5·0	12	23	good
5357	10	17 37	C	− 3·4	13	26	good
5363	12	17 45	P′-C	− 2·6	7	26	fair
5373	17	16 37	P′	+ 0·3	12	53	fair
5388	23	16 32	P	− 11·3	14	37	good
5395	24	17 50	P′	− 7·6	10	24	good
5402	25	17 37	H	− 11·7	9	37	good
5414	Mar. 3	17 10	P′	− 3·3	9	50	good
5419	7	17 30	C-P′	− 7·3	5	18	fair
5430	11	17 20	C-P′	− 12·5	6	36	fair
5435	12	16 37	H	− 8·2	6	14	fair
5439	17	15 52	P′	− 5·7	6	15	fair
5448	Apr. 7	15 03	C	− 0·4	7	34	fair
5457	9	14 55	C	− 4·0	8	28	fair
5470	14	15 25	P′	− 16·7	11	31	good
5490	17	15 16	H	− 15·1	5	41	poor
5492	20	14 45	P	− 18·3	13	36	fair
5497	21	13 57	C	− 9·7	4	25	poor
5504	24	13 20	H	− 10·4	6	22	fair
5522	May 1	13 26	H	− 5·5	9	28	fair
5528	2	13 20	C	− 12·7	2	1	poor
5537	7	13 22	C	− 22·3	2	15	poor
5550	14	13 50	P	− 15·3	8	29	fair
5852	Dec. 22	20 41	C	− 10·2	10	49	fair
	1914						
5888	Jan. 12	19 15	C	− 8·5	3	13	poor
5915	Feb. 5	17 44	Y-H	− 8·7	11	34	fair
5933	12	17 10	H	− 7·3	6	36	fair
5937	14	16 40	P	− 18·7	4	44	poor
5958	23	17 14	C-P′	− 8·1	9	20	good
5963	24	18 29	H	− 11·8	7	35	good
5966	27	18 20	P′	− 33·0	7	34	good
5968	Mar. 3	18 19	P′	− 21·3	8	22	good
5974	11	15 36	Y	− 23·2	9	31	good
5976	13	17 04	C	− 23·5	9	29	good
5978	16	14 57	P′	− 27·1	9	34	good
5988	20	16 35	C	− 19·5	10	21	good
5995	23	15 17	P′	− 16·4	10	38	good
6009	Apr. 3	15 20	C	− 23·1	9	21	good
6067	May 8	14 50	C	− 14·2	6	19	good
6525	Oct. 22	21 06	Y	− 6·4	10	37	good
6565	Nov. 17	23 00	Y	− 9·0	9	46	fair
6576	23	23 09	P′	− 23·8	7	39	good
6611	Dec. 10	22 47	Y	− 0·5	6	24	good
	1915						
7385	Nov. 6	21 33	Y	− 15·7	8	27	good
	1916						
7529	Feb. 29	16 56	H-Y	− 8·1	12	24	good
7530	29	17 43	H	− 11·3	9	21	good

P = J. S. Plaskett. P′ = Parker. C = Cannon. H = Harper. Y = Young.

The binary character of α Cancri was announced by the Mt. Wilson Observatory in the *Astrophysical Journal*, Vol. XXXV. The star was placed on the observing program here by Mr. Parker. The announcement gave a range of nearly sixty kilometers (− 59 to − 2). The 48 plates obtained did not show the same range and a letter from Dr. Adams states that there was a mistake in computing the reduction to the sun for those velocities upon which the variation announced was based. The removal of the error leaves the velocity constant, − 8·2 km. The Allegheny Observatory gets a mean velocity for this star − 18·5 km. from four plates.

The 48 plates taken at Ottawa yield a mean velocity − 12·2 km. ± 0·73. The range is 33 kilometers. The spectral lines are of very poor quality and it is impossible to say whether the observed range indicates that the star is binary or not. It will be noticed that the plates taken in the first months of the year 1913 yield consistently a higher positive velocity than those during March, 1914.

About half of the plates taken of this star were measured by Mr. Parker. On his leaving for the Front the star was taken over by the writer and the remainder of the plates measured. The following table gives a list of the corrected wave-lengths of lines used in reducing the measures.

Corrected Wave-Lengths

4005·55	4198·80	4326·00
4045·91	4202·05	4340·69
4063·58	4227·01	4352·01
4071·00	4215·71	4395·39
4077·70	4233·37	4481·46
4101·89	4271·65	4549·63
4143·69	4290·16	

22 Bootis

($\alpha = 14^h\ 21^m{\cdot}8$, $\delta = +\ 19°\ 41'$, Mag. 5·36, type *A*5)

Plate	Date	G.M.T.	Observer	Velocity	No. of Lines	Range	Quality
	1915	h m					
6950	Apr. 21	18 51	Parker	− 29·3	13	19	good
6971	May 6	18 45	Young	− 31·1	11	23	good
6981	May 10	17 55	Parker	− 27·1	17	22	good
7035	May 31	15 20	Parker	− 23·2	14	14	fair
7078	June 29	14 02	Young	− 32·9	13	15	good

α2 Librae

($\alpha = 14^h\ 45^m{\cdot}3$, $\delta = -\ 15°\ 38'$, Mag. 2·90, type *A*2)

Plate	Date	G.M.T.	Observer	Velocity	No. of Lines	Range	Quality
	1917	h m					
8029	Feb. 1	20 52	Young	− 47·1	6	48	good
8030	" 1	21 24	Young	− 46·2	7	41	good

Announced as binary from Lowell Observatory, Lowell Observatory *Bulletin*, No. 11. The complete published range from velocities at the Lowell and Yerkes Observatories is 86 kilometers (+ 26 to − 60).

B.D. 55°·1793

($\alpha = 15^h\ 55^m{\cdot}4$, $\delta = +\ 55°\ 2'$, Mag. 4·96, type *A*5)

Plate	Date	G.M.T.	Observer	Velocity	No. of Lines	Range	Quality
	1915	h m					
7112	July 20	15 23	Young	− 21·5	5	26	fair
6911	Apr. 7	21 28	Parker	− 30·0	6	42	fair
6926	" 14	16 35	Harper	+ 3·3	3	52	poor
6942	" 20	18 45	Harper	− 29·0	7	38	fair

Observation of this star is being continued at the Yerkes Observatory, cf. *Astrophysical Journal*, Vol. XXXIX. All the plates taken here are rather inferior and the velocities consequently not so reliable as they would be with good exposures.

ζ Ophiuchi

($\alpha = 16^h\ 31^m{\cdot}7$, $\delta = -10°\ 22'$, Mag. 2·70, type *B*)

Plate	Date	G.M.T.	Observer	Velocity	No. of Lines	Range	Quality
	1916	h m					
7705	June 25	13 57	Young	− 11·3	1		good
7709	June 29	14 29	Young	− 18·6	1		good

The plates of which velocities are given above are two of several taken of this star. The spectrum is almost continuous and so far as the writer knows no velocities have been published. On two of the plates the *K* line of calcium looks measurable being faint and rather narrow.

102 Herculis

($\alpha = 18^h\ 4^m{\cdot}4$, $\delta = +20°\ 48'$, Mag. 4·32, type *B*2)

Plate	Date	G.M.T.	Observer	Velocity	No. of Lines	Range	Quality
	1916	h m					
7690	June 6	14 57	Young	− 16·2	9	22	good
7694	June 13	14 35	Young	− 27·0	13	27	good

Announced as spectroscopic binary by the Lick Observatory. Lick Observatory *Bulletin*, Vol. VI., p. 199.

Boss 4842

($\alpha = 18^h\ 57^m{\cdot}7$, $\delta = +50°\ 23'$, Mag. 5·24, type *B*3)

Plate	Date	G.M.T.	Observer	Velocity	No. of Lines	Range	Quality
	1915	h m					
6977	May 9	20 39	Harper	− 22·3	9	20	good
7000	May 15	19 00	Young	− 29·2	7	7	good
7019	May 27	19 20	Young	− 22·6	11	24	good

Dominion Observatory,
Ottawa, Canada

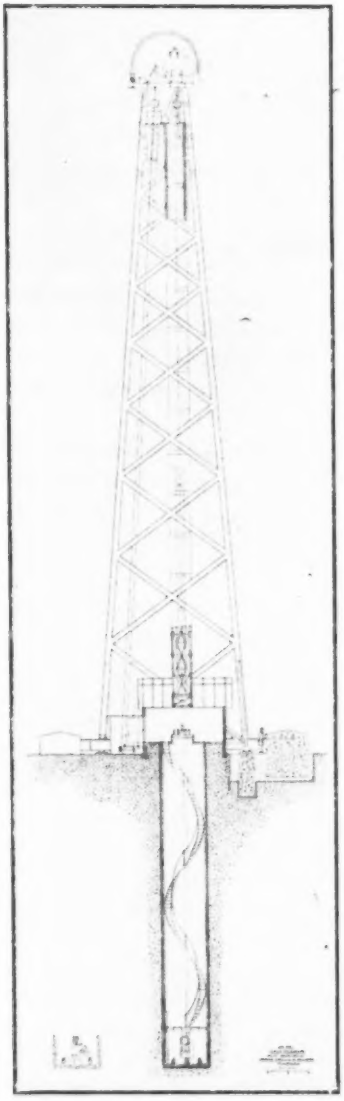
THE 150-FOOT TOWER TELESCOPE OF THE MOUNT WILSON SOLAR OBSERVATORY

By Adriaan van Maanen

WORK with the 150-foot tower telescope of the Mount Wilson Solar Observatory has now been carried on for about five years, and it seems appropriate to give a résumé of the principal results yielded during that time, together with a brief description of the instrument itself.

The principal objection to a horizontal telescope had been found to be the blurring of the image of the sun due to the effect of the heated air from the earth. To obviate, or at least to reduce, this difficulty a vertical telescope 60 feet in height was devised and constructed in an inexpensive way in 1907. This has been described by Mr. Hale in *Contribution* No. 23 of this Observatory. The success of this first tower telescope indicated that the construction of a more powerful instrument would be fully justified. The building of a 150-foot tower telescope was accordingly begun as early as 1909, but it was not ready for use before January, 1912, on account of the long delays occasioned by the difficulty in obtaining a suitable object glass of 150 feet focal length. This considerable focal length gives an image of the sun as large as sixteen inches, which of course is very favorable for the study of details. Another improvement of the new tower is the 75-foot spectrograph, mounted in a well, beneath the the tower. With this spectrograph we have a dispersion so large that the visible spectrum (λ3900 to λ7000) is about 50 feet long in the third order of the grating used. Another advantage of the underground spectrograph is that the variation in temperature is very small, not exceeding one degree centigrade during the year.

The tower is of double skeleton construction, one inside the



CROSS SECTION OF THE 150-FOOT TOWER TELESCOPE

other; the two towers, with the members nowhere touching, are founded on separate concrete piers. In this way the necessary steadiness has been secured notwithstanding the great height. The outer tower carries the revolving dome; this can, therefore, be turned around during the observations without jarring the inner tower and blurring the solar image; it also protects the inner tower from being shaken by the wind. An elevator makes it possible to reach the top.

The accompanying diagram shows a cross section of the instrument; in order not to overcrowd the picture the structure of the inner tower has been omitted except at the lower right-hand. Plates XI. and XII. show respectively the construction of the lower part of the tower and the finished instrument; in the first the construction of the two towers can be clearly seen.

The optical parts are mounted at the top of the inner tower; a cœlostat-mirror of 19 inches diameter and a thickness of 13 inches sends a beam of sunlight to a second flat mirror of 15 inches diameter and a thick-

ness of 11 inches, from which it is reflected vertically downward to a 12-inch objective of 150 feet focal length. This forms an image of the sun of more than 16 inches diameter in the observing-room at the foot of the tower. Here is found the slit of the spectrograph about 3 feet above the floor; passing through this slit the light descends to a collimating lens of 75 feet focal length mounted near the bottom of the pit; directly below this lens is a grating, ruled by Michelson and containing about 15800 lines to the inch; from the grating the light is returned through the collimating lens, which, as in all autocollimating spectrographs, serves also as a camera objective, and forms an image of the spectrum on a photographic plate, mounted beside the slit of the spectrograph. Forty inches of spectrum can be photographed with a single exposure.

By using different orders of the grating, and by the possibility of inserting in the spectrograph a collimating lens of 30 feet focal length instead of that of 75 feet, the dispersion can be greatly varied for different purposes. It is also possible to remove the lens at the top of the tower and to insert in the beam of sunlight one of another focal length, either 60 or 30 feet. In this way we are enabled to produce images of the sun about 7 and 3½ inches in diameter, respectively.

The cœlostat and second flat mirrors have been made unusually thick in order to avoid, or at least reduce, the astigmatism of the mirrors due to the heating effect of the sunlight. For the same purpose both mirrors are surrounded on the sides and on the bottom by water-jackets in which water of a nearly constant temperature can be kept circulating by a pumping device. These precautions have proved to be extremely useful.

From the base of the tower near the slit of the spectrograph the observer can, by electrical devices, make practically all the necessary changes in the instrument. From there he can control the fast and slow motions of the cœlostat and second flat mirrors; he can focus the objective, start the cœlostat-clock and the pump for circulating the water, and turn the dome. From the same place he is able also to focus the autocollimating lens, tilt the

grating and rotate it. In this way the instrument, once ready for use, does not need, during the day's work, any re-adjustment which requires the observer to go either to the top of the tower or the bottom of the pit.

The large image of the sun has proved to be very useful for several purposes, while the enormous dispersion of the spectrograph has yielded an accuracy not before attained.

Since its completion the instrument has been used for a variety of work ; the principal results will be enumerated briefly in the following pages.

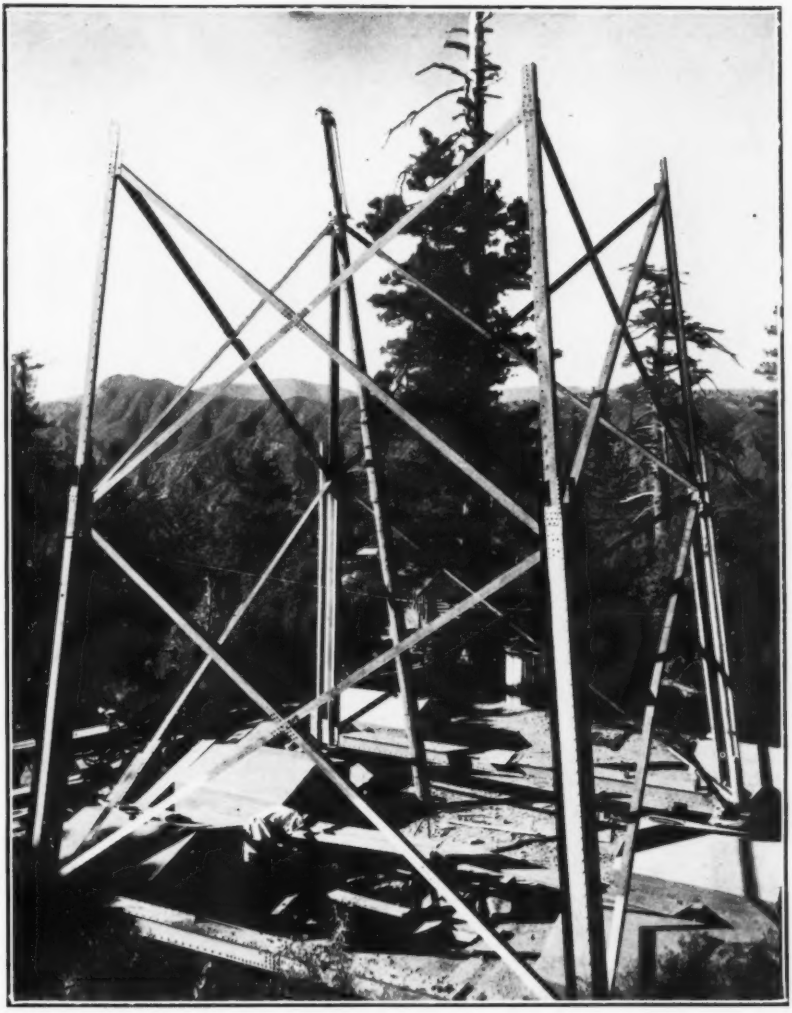
1. THE "FLASH" SPECTRUM WITHOUT AN ECLIPSE

Up to 1891 our knowledge of the chromosphere spectrum depended entirely upon the observations made during total eclipses of the sun. The chromosphere layer is so thin that it is covered in a very few seconds by the passage of the moon's disc over that of the sun. The available time for studying its spectrum is, therefore, extremely short. In 1891, Mr. Hale made a first attempt to photograph this spectrum in full daylight. As the spectrograph slit must be held exactly at the edge of the limb, success depends largely on the possibility of securing good definition of the sun's image. It is clear that a large image of the sun will facilitate this work, while a high dispersion will improve the accuracy of the results. A great deal of work in this line had been done with the 60-foot tower telescope, but it was thought that improvements could be made with the 150-foot tower. Accordingly, some plates were taken to determine with greater accuracy the wave-length, level, and origin of all the bright lines that can be photographed with this high-dispersion instrument. Because the tower has been required for other work the results are as yet incomplete, but as far as the plates have been measured they are very promising.

2. SOLAR ROTATION

Observation of solar rotation with the 150-foot tower was begun in 1914 by Mr. Adams, Mr. St. John and Miss Ware.

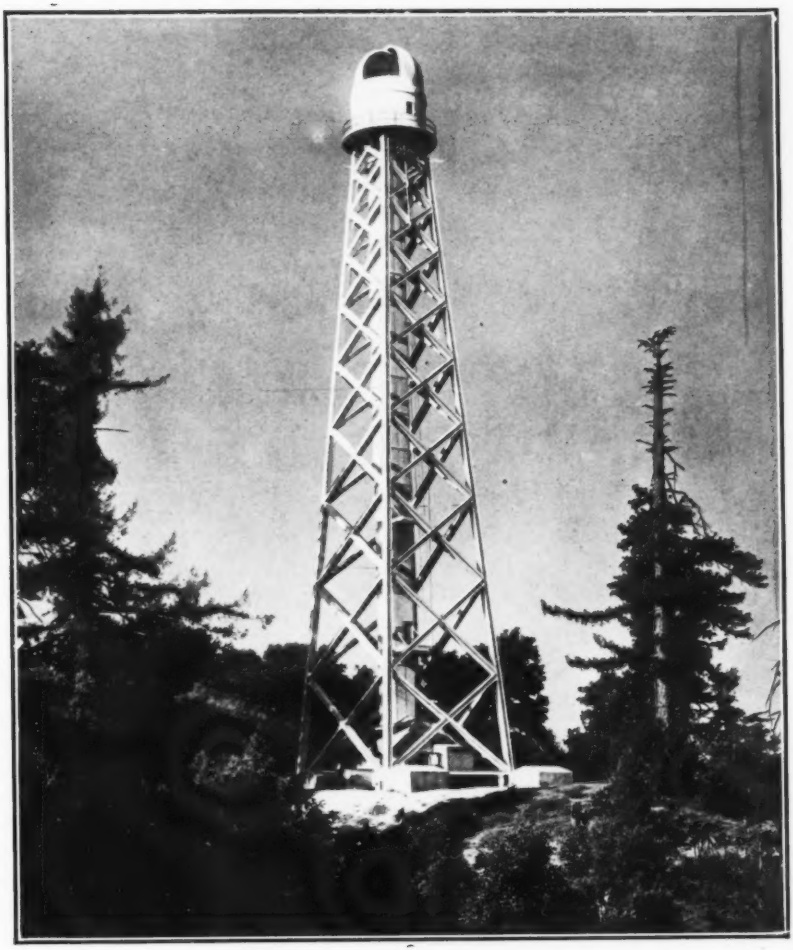
PLATE XI.



THE 150 FOOT TOWER TELESCOPE UNDER CONSTRUCTION

Journal of the Royal Astronomical Society of Canada, 1917

PLATE XII.



THE 150-FOOT TOWER TELESCOPE

Journal of the Royal Astronomical Society of Canada, 1917

On account of the large image of the sun it is possible to photograph with great precision the light from a point at a certain distance from the sun's limb (in this case 3 mm.). The results obtained so far confirm the earlier measures by Mr. Adams and Miss Lasby showing different rotation periods for the lines of different intensity, the stronger lines yielding the higher relative values. For the three magnesium lines of the *b* group, for instance, the equatorial velocity was found to be 2·043 km. per second, while for 22 lines of intensity 1 to 7 the mean equatorial velocity was 1·934 km. per second. As such differences, depending on the intensities of the lines, were not shown by measures made at other observatories, it seemed desirable, as a precaution against possible physiological errors, that a wholly independent test should be made. Some typical lines have, therefore, also been measured with the Koch microphotometer; the results show differences of the same order as the filar-micrometer measurements.

3. SUN-SPOT SPECTRUM

The 150-foot tower had been completed before the revival of the activity of the sun. As soon as the sun-spots became more numerous the new instrument made it possible to take photographs of spot spectra on a considerably larger scale than before, while the large solar image enabled us to undertake a more detailed study of the spectra of different parts of the spots.

The Zeeman effect in spots had been recognized before by Mr. Hale; an attempt could, therefore, be made at once to secure a map revealing many details due to the magnetic field in the spots. For this purpose the photographs were made with a compound quarter-wave plate in conjunction with a Nicol prism placed just above the slit of the spectrograph. The elliptically polarized red and violet components of lines in spots near the center of the sun are in this way alternately cut off, or at least reduced in intensity, by the odd and even strips of the quarter-wave plate. This phenomenon, combined with the behavior of the same components when the spot is approaching the

edge of the sun, have proved that the spot-vortex is approximately radial to the sun's surface, while the strength of the magnetic field is found sometimes to attain a maximum of 6000 gausses. The dispersion and resolution of the 75-foot spectrograph are sufficient to show in some cases as many as five components.

Plates for the larger part of the spot spectrum have been secured by Mr. Ellerman and his collaborators. Plate X III., *a*, represents a part of this spectrum in its original size (taken in the second order of the grating), showing the D lines at the red end. Of late, at the suggestion of Mr. Nicholson, a simple plane parallel-plate micrometer has been added to the equipment of the tower for the measurement of the separation of the components of several lines, in order to get a better idea of the strength of the magnetic field in different spots. These observations are made in conjunction with the investigation by Mr. Babcock of the separations of various lines produced by a magnetic field of known strength in the laboratory.

4. SUN-SPOT POLARITIES

Soon after the discovery of the Zeeman effect in spot spectra, it was noticed that different spots showed differences in polarity, some transmitting the red, others the violet component through the even strips of the compound quarter-wave plate. At first it seemed that this might be due to the position of the spots on the sun's surface, those in the two hemispheres having different polarities. With increasing material this supposition had to be abandoned, since spots of both polarities appeared in each hemisphere.

It had long been known that many spots occur in pairs, and upon further examination it was found that in nearly all cases the preceding and the following spots of a pair show different polarities. This fact induced Mr. Hale to adopt the working hypothesis that all spots tend to assume the bipolar form, the companion or following spot, in the case of apparently single spots, often failing to develop completely. The material at hand

then showed that the polarities of all the preceding spots, with very few exceptions, were the same in a given hemisphere, but opposite to those of the preceding spots in the other hemisphere. After the sun-spot minimum in 1913 the remarkable fact was found that the polarities in the two hemispheres were the reverse of those before the minimum. The possibility that this change might be due to differences in latitude, the last spots of the old cycle usually appearing near the solar equator and the first ones of the new cycle being found in high latitudes, was proved not to be the true explanation as soon as spots of the new cycle began to appear in lower latitudes, for their polarities were the same as those in the higher latitudes. As the large scale of the solar image with the 150-foot tower has made it possible to determine the polarities of even very small spots, material for this investigation is rapidly accumulating and it is hoped that the problem of the reversal of the polarities will soon be unraveled.

5. GENERAL MAGNETIC FIELD OF THE SUN

A great deal of the time of the new tower has been devoted to the general magnetic field of the sun, a problem in which Mr. Hale has been deeply interested ever since the discovery of magnetic fields surrounding sun-spots. The quiescent condition of the sun in 1912 to 1914 made it possible to secure thousands of spectra for the purpose of determining if there were any Zeeman effect which would indicate the existence of a general magnetic field, as might be anticipated from the presence of free electrons carried round by the sun's rotatory motion. The measures of many photographs have given strong positive results. Practically all plates were taken in the third order of the 75-foot spectrograph, using the large image of the sun. For the earlier photographs the slit, which is made to coincide in direction with the sun's axis, usually had its middle point at 45° north or south latitude. These latitudes are near the points of maximum theoretical displacement, due to the extinction by the Nicol and compound quarter-wave plate of the circularly polarized red and violet components of the lines.

From these measures, which were discussed in detail by Mr. Hale in Mount Wilson *Contribution*, No. 71, it seemed quite safe to conclude that the sun behaves approximately as a spherical magnet, with its poles falling near the poles of rotation. An approximate determination of the strength of this magnetic field from four lines of intensity 0, 1, and 2 gave a value of about 50 gausses for the vertical component at the poles. Hence the sun's field at the level of the lines in question is about 80 times as strong as that of the earth, while the polarity of both bodies has the same sign.

More than 40 lines of different elements in the region between λ5200 and λ6600, including iron, chromium, nickel, vanadium and calcium, have now been measured by the writer; 25 of these lines, of intensities ranging from 0 to 5, showed opposite displacements for the northern and southern hemispheres of the sun, with maximum displacements at about 45° latitude north and south. A reproduction of one of the photographs, two-thirds full size, is given in Plate XIII, *b*. As some brighter solar lines, which show a strong Zeeman effect in the laboratory, have failed to show this effect in the measures of the solar plates, it seems probable that the layer of the sun producing the Zeeman effect is extremely thin. This failure, however, may be due to a physiological difficulty in measuring the lines of greater intensity. More work along this line, in which Koch's microphotometer is likely to be of great help, must still be done.

After the establishment of the general magnetic field it was thought most important to begin an investigation for the determination of the position of the sun's magnetic axis and the value of its period of revolution about the sun's axis of rotation. From June to September, 1914, plates covering the sun's meridian from 45° north to 45° south latitude were taken practically every day under the direction of Mr. Ellerman. The measurement by the writer of three selected lines on these photographs is nearing completion. The smallness of the displacements has made it necessary to include thousands of plates, a circumstance easily understood when it is stated that the maximum displacement is

PLATE XIII.

(*a*) Photograph of part of the sun-spot spectrum, second order, original size.

(*b*) Photograph of part of the solar spectrum used for the determination of the general magnetic field of the sun, third order, two-thirds the original size.

λ5856·312 was found to show the Zeeman effect ; λ5892·920 seems to be unaffected by the sun's general field.

0·001 A and that in attempting to locate the axis we are dealing with quantities of the second order. To Mr. Seares is due the derivation of the necessary formulæ and the superintendence of the reductions; a preliminary discussion based on part of the data (observations on 37 days, covering an interval of about two and one-half months) has given the following provisional values :—

$$\text{Period} = 31^{d}\cdot 51 \pm 0^{d}\cdot 62$$
$$\text{Inclination} = 5^{\circ}\cdot 2 \pm 0^{\circ}\cdot 5$$

The completion of the investigation will require more time, but the existence of the general field and the inclination of the axis may be said to be established with fair accuracy.

MOUNT WILSON SOLAR OBSERVATORY,
PASADENA, CAL.

CLOCK SYNCHRONIZATION

By R. M. Stewart

IN the last issue of this JOURNAL there was described a simplified form of the type of clock synchronization which depends on the use of small correcting weights on the pendulum, originally devised by the writer of this note. It is the present purpose to make a few remarks on this simplification in particular, and on some other points of interest in connection with this type of synchronization.

In order that any type of synchronization may be entirely satisfactory, it is necessary to fulfil the condition that the cutting off of the synchronization, either by accident or design, may leave the controlled clock free to keep time to the best of its ability. This is especially necessary where the number of controlled clocks is comparatively large, and where their distances from each other and from the controlling clock are considerable.

If, however, one is satisfied to dispense with this condition, as is done in Blake and Jackson's form mentioned above, the mechanism may, of course, be much simplified. In this connection it may be interesting to describe a form which was examined and rejected when our new synchronization was first installed. *A* (Fig. 1) is the synchronizing contact (or relay), closed every alternate second; *B* is the minute contact on the controlled clock, in which the arm rests normally on 2, but is drawn against 1 for a second (or less) every minute, returning to 2 on the 60th or zero second; *R* is a resistance large enough to prevent the armature of *C* from being drawn up from its lowest position when *A* is closed, but small enough to enable it to be held at its highest position after being drawn up. It will be readily seen that between the 59th and 60th seconds, when *B* is on 1 and *A* is closed, the armature of *C* will always be up, hold-

ing the weight D off the pendulum; if A opens first (controlled clock slow) the circuit is opened and D falls on the pendulum and remains there; if B crosses to 2 while A is still closed (con-

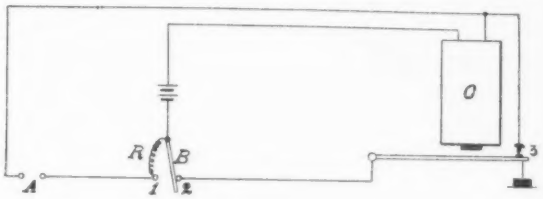


FIGURE 1.

DEFECTIVE SYNCHRONIZATION

trolled clock fast), the current through R is sufficient to hold the armature of C until B reaches 2 and the short circuit at 3 comes into operation, so that D remains off. If, however, the synchronizing line fails, A will remain continually open or closed, and D will remain continually on or off the pendulum as the case may be, making the clock run wrong. This arrangement, which is thus open to the same objection as that of Blake and Jackson, was therefore rejected, and two* additional relays were introduced to overcome the difficulty, giving the arrangement as originally published.†

For controlling a "Magneta" clock, which emits an instantaneous magneto current every minute, reversed in direction each minute, a somewhat similar arrangement has been in use here for some years. The electric contact of the controlled clock is here replaced by the magneto circuit, which serves to set the "controlling" relay D,‡ while an additional polar relay is required to open the local circuit every alternate minute, the synchronization thus being effective only during alternate min-

*Only two additional relays are required, not four, as might be inferred from Blake and Jackson's article.

†This JOURNAL, Vol. VII., p. 289.

‡This JOURNAL, Vol. VII., p. 289.

utes. It would, of course, have been optional to install in the Magneta clock an electric contact operated once a minute, and use the original arrangement.

The simplest case of all is that in which both the controlling and the controlled clocks are of the Magneta type; in this case an arrangement somewhat similar to that described by Blake and Jackson, but without the objectionable rubbing contacts at the points of the polar relay, may be used. *A* (Fig. 2) is a neutrally adjusted polar relay worked by the controlling clock; its armature thus rests on 1 and 2 during alternate minutes; *B* is the

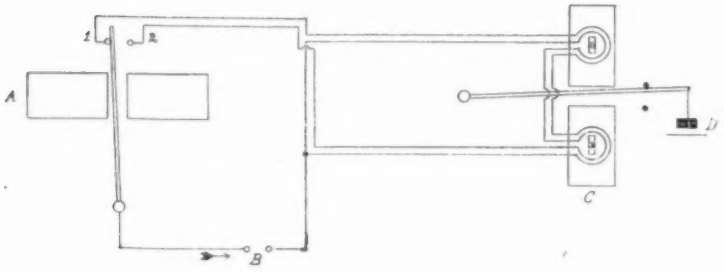


FIGURE 2.

SYNCHRONZIATION OF ONE MAGNETA CLOCK BY ANOTHER

magneto circuit of the controlled clock. Suppose that the armature of *A* passes from 1 to 2 at the same minute that the current generated at *B* passes in the direction indicated by the arrow; if, at the instant the current flows through *B*, the armature of *A* has not yet left 1 (controlled clock fast), the current passes upward through the outer coils of *C*, lifting *D* off the pendulum; if, on the other hand, the armature of *A* has already reached 2 (controlled clock slow), the current passes downward through the inner coils of *C*, dropping *D* on the pendulum; at the following minute the current through *B* is reversed, while the armature of *A* is passing from 2 to 1, so that the operation is similar.

Also, if the synchronizing line is cut off, the armature of *A* remains continually in the same position, so that *D* is successively on and off the pendulum during alternate minutes, and the controlled clock runs with its normal rate.*

There is only one point in the above which would have seemed doubtful to the writer; that is, whether the current generated by the Magneta clock is sufficiently powerful to operate a polar relay with the weight hanging on the armature, especially as the motion of the armature must necessarily be small, and consequently the shelf must be near the upper extremity of the pendulum, thus entailing the use of a heavier weight than if it could be placed lower. As, however, a polar relay is apparently in use for this purpose by Blake and Jackson, this point may be considered settled. In any case, the polar relay *C* could be used to operate another relay of the ordinary type to lift the weight.

The synchronization of an ordinary clock by one of the Magneta type is more difficult, but could be arranged by the substitution for *B* of a local battery, to be used in combination with two contacts in the controlled clock, one closing the circuit for a second or less every minute, the other throwing the circuit into a different path during alternate minutes.

*A similar arrangement could also be used for controlling a Magneta clock by an ordinary one, if the latter were equipped with a suitable electric contact.

DOMINION OBSERVATORY,
OTTAWA, CANADA.
May, 1917.

MEETINGS OF THE SOCIETY

At Toronto.

March 6, 1917.—A regular meeting of the Royal Astronomical Society of Canada was held in the Society's Rooms, 198 College St., at 8 p.m. Mr. A. F. Hunter in the chair.

The following were elected members of the Society :—

Miss Eva Smith, 12 Westmoreland Ave., Toronto.

C. R. Harris, Elm Grove Ave., Toronto.

H. M. Lye, 49 Dupont St., Toronto.

Miss F. Hahn, 52 Duggan Avenue, Toronto.

The paper for the evening was presented by Mr. J. Patterson, M.A., of the Meteorological Service, on "Long Range Forecasts and Other Weather Illusions." After referring briefly to the growth of astrology out of the facts observed by primitive man, the lecturer showed by a mathematical demonstration of the energy required to produce our annual rainfall that the sun must be the only source of power and that all laws of weather based on astrology must fail.

In the second part of his paper he treated of the advances made in the study of meteorology as a result of upper air investigation, and showed how the early theories based on surface knowledge of cyclones and anti-cyclones were also proven to be illusions. The paper was illustrated by lantern slides.

March 20.—A regular meeting was held in the Physics Building of the University, at 8.15 p.m. Dr. A. D. Watson in the chair.

The following were elected members of the Society :—
Ernest Watson, 718 Shaw St., Toronto.
Miss F. Mabel Ashall, 442 Sherbourne St., Toronto.
Wm. J. Wattman, 257 Mutual St., Toronto.

The lecturer of the evening, Rev. Robert Norwood, of London, Ont., was then called on by the President to speak on "The Mythology of the Stars." The lecturer introduced his subject with the statement that the mentality of all ages is directed by the Eternal Thinker, "myths are merely symbols whereby knowledge or profound truths are taught to those desirous of learning." He then stated that the myths of the zodiac are symbols telling the story of the human soul, and gave his interpretation of the myths beginning with Virgo and Boötes and going through the twelve signs of the Zodiac to Leo. He then read one of his poems on the Zodiac.

April 3.—A regular meeting was held in the Society's Rooms, 198 College St., at 8 p.m. Mr. A. F. Hunter in the chair.

Several members referred to the frequency of solar and lunar halos seen during March.

Dr. Satterly, of the University of Toronto, was called on for his paper on "Telescopes for All and How to Make Them." He explained the principle of the astronomical telescope and illustrated it by blackboard brawings, and then exhibited in detail a telescope and sextant which he himself had made whilst a student in London.

Following the paper several questions on the construction of telescopes were asked by members present which the lecturer satisfactorily answered.

April 17.—A regular meeting was held in the Society's Rooms, at 198 College St., at 8 p.m. Dr. A. D. Watson, President, in the chair.

The following were elected members of the Society :—

G. W. Winckler, Assoc. M.I.C.E., Eng., 16 Wellsboro' Apts., Jarvis St., Toronto.

Rev. A. K. McLeod, Brighton, Ont.

A very complete lunar halo was reported by Mr. Hunter to to have been observed on April 7.

Mr. A. F. Miller gave the lecture for the evening on the subject "Stellar Parallax." The lecturer defined parallax and illustrated his remarks with blackboard drawings, and then traced the development of the knowledge of parallax from the time Aristarchus attempted to find the sun's distance down to the present. Using the diameter of the earth's orbit for base line, he then defined Stellar Parallax and referred to the work of Flamsteed, Rochmer, Robert Hook, and Bradley in their attempts to find the parallax of stars, and their finding of an apparent motion of the stars in an ellipse of 40″ diameter which Bradley determined was caused by light aberration.

May 1.—A regular meeting was held in the Society's Rooms, at 198 College St. Dr. A. D. Watson, President, in the chair.

The following were elected members of the Society :—

J. R. Taylor, 48 Borden St., Toronto.

Geo. E. Barnes, 96 Langley Ave., Toronto.

H. G. Kendall, 17 Watson Ave., Toronto.

The lecture for the evening was given by Dr. Marsh on "Astronomy for Beginners." He dealt with the care and use of instruments and observations most useful to beginners, and illustrated his remarks with blackboard drawings.

May 15.—A regular meeting was held in the Society's Rooms, 198 College St., at 8 p.m. Dr. A. D. Watson, President, in the chair.

The following were elected members of the Society :—

Rev. T. H. Cotton, M.A., Wycliffe College, Toronto.

James B. Hammond, Nairn Centre, Ont.

John Flower, Welland. Ont.

Referring to the recent easterly elongation of Mercury, which was greatest on April 24, Professor Chant reported that the planet was seen by Mr. F. C. Hamilton first on April 13 and last on May 3.

A large number of sun-spots were reported, during the last two weeks, by different members.

The lecture for the evening was by Dr. Ralph E. DeLury, of Ottawa, on "Solar Rotation." He introduced his subject by stating that two methods have been used to determine rotation, and by means of lantern slides he illustrated the methods and results obtained. The first method is by tracing the motion of spots; and the second method by means of measuring the displacement of spectrum lines. The lecturer stated that the result of analysis pointed to scattered light as being responsible for differences in the measures obtained and that probably the true value of rotation was slightly higher than the observed and may be about 2·1 km. per second or slightly higher. A by-product of the investigation is the determination of the sun's distance.

W. E. W. JACKSON, *Rec.-Sec.*

AT OTTAWA

December 29, 1916.—The fifth meeting of the fall term was held at 3 p.m., in the Geodetic Survey Building. The subject, "Solar Rotation," was given by Dr. R. E. DeLury.

The values of the sun's rate of rotation obtained by the observation of spots and clouds of various kinds and of displacements of the spectrum lines were summarized and presented in tabular form. A great range in values was found. These differences had been explained as due to error, variation in the sun's rotation and differences in level in the sun of the elements producing the spectrum lines,— it being assumed that increase in level in the sun was accompanied by increase in the angular velocity.

While admitting that a strong case had been put forward by the Mt. Wilson workers in support of their level hypothesis, Dr. DeLury attempted to show that if one were to assume a vari-

able spectrum such as that produced by haze, to be blended with the limb spectrum, one could account not only for the facts explainable by the level hypothesis but also for the great range of values obtained for rotation period. Measurements which the lecturer had made of limb and centre spectra blended together, showed that the lessening of the displacements of the limb spectrum lines increased with decrease in intensity. This was also found in his observations of the solar rotation on hazy days while the effect was nearly absent on the brightest days. This would make it seem probable that the source of the variable blended spectrum was terrestrial. This would then involve the assumption that the Mount Wilson values for the same lines suffered also from the presence of a similar blended spectrum. It was explained that strong lines in the red part of the spectrum should yield the highest values. This is found to be the case in general. It was pointed out that values of the solar rotation lessened by haze spectrum could be corrected on knowing the magnitude of the difference between the weak and the strong lines, and that probably the majority of observations yielded values several per cent. too low.

After the paper followed an animated discussion. Dr. J. S. Plaskett pointed out the fact that the measures for haze at Mt. Wilson had showed that there was seldom more than a one per cent. haze at that place. This he said would not affect the measures sufficiently to be noted. In reply Dr. DeLury pointed out that if this measure referred to the times necessary to obtain equal intensity on a photographic plate, it would mean that the sky spectrum was, for a normal plate four per cent. as strong as the limb spectrum. Moreover that as this referred to continuous spectrum there would be a still higher relative strength in referring to those lines which were weak, and were as much as three times the relative strength in the haze spectrum as in the limb spectrum.

January 26, 1917.—The first meeting of the spring term. The lecture for the day was given by Mr. J. J. McArthur, D.L.S.,

the President, his subject being "Reminiscences of an Exploring Trip in the Yukon, along the Base of the St. Elias Alps."

The lecture was illustrated by lantern slides and diagrams, and dealt with the experiences Mr. McArthur met with in making the first exploration survey through the country along the St. Elias Alps. In describing the country, reference was made to a formation which was found along the Fraser and other rivers. On one bank there were outcrops of rock and this had been covered with earth and this again by forests. The other bank, however, presented the strange sight of a long ridge of ice at right angles to the river. Where this ridge met the river it presented a sheer face of ice fifty feet high. The top of the ridge was covered with about six feet of ice on which forests of trees, some of them as great as two feet in diameter, flourished. As the sun melted the face of the ice, parts of the earth kept constantly falling into the river below. Occasionally a tree which had become undermined toppled over also. The stories told of the trips taken and the difficulties overcome were interesting indeed and the attendance was much greater than is usually present at an afternoon meeting of the Society.

February 2.— The President was in the chair. The lecture for the afternoon was given by Mr. A. Steadworthy, of the Observatory staff, on the subject "Some Problems in Photography."

The first half of the lecture dealt with the difficulties met with by the professional photographer. The last half dealt with the details of the photographic processes.

In discussing the difficulties of the professional photographer, Mr. Steadworthy gave a very amusing account of the trials of the operator who must take pictures all day with all sorts of variations in light and subject. He dealt with the dissatisfaction of same sitters who were anxious to have as good looking a picture as someone else had obtained but who were not qualified by nature. Then there were those who demanded profile sittings when they should be full face or *vice versa* and last but not least the child accompanied by a retinue of female relatives.

The photographic processes of tank development, taking lightning pictures and the combining of negatives for freak pictures were touched upon. A picture was shown which the lecturer had made by combining a daylight picture of a train with a daylight picture of a storm to obtain a night picture of a train rushing through a storm. The result was very fine and the audience could well believe that something like six months had been required to make the details work out so well.

February 16.—The third lecture of the spring term was held in the Normal School. The President was in the chair. Dr. J. S. Plaskett gave an illustrated lecture on "Canada's Great Reflecting Telescope."

This was the first time the lecture had been given in a popular way in a down town auditorium. The fact that the telescope has been completed with the exception of the mirror and that the photographs of the location, the observatory dome and the mounting were available made the lecture very interesting indeed. There was a good attendance.

March 2.—The President was in the chair. The lecture of the afternoon was "Kindergarten Lessons in Practical Astronomy," by Mr. Thos. Fawcett.

The lecturer dealt with some of the very elementary and simple points in practical work which the surveyor is apt to take for granted he knows, but which the examination papers of candidates for Land Surveyors shows to be rather hazy to some.

March 16.—The President was in the chair. Mr. R. M. Stewart gave a most interesting paper on "Time and Clocks."

The details of the methods of determining time from observations of the stars and the instruments used in that work were first described and illustrated by means of lantern slides. The different types of transit instruments and chronographs were described. The chronograph used at the observatory in which the time of transit of the various wires by the star is printed on

a slip of paper was shown by means of a slide, and its record explained. This type of chronograph does away with scaling, which is the most tedious process of the work.

The latter part of the lecture dealt with the types of clocks and their synchronization with a master clock. The latter, with its elaborate system for maintaining a uniform rate, was a very interesting point. The details of the synchronization of the master and submaster clocks and the method of controlling the electric time dials of the system by means of the latter were explained. The lecturer pointed out that great care was necessary in order that these many dials should be kept in time, and said that he wished to take that opportunity of giving Mr. Dier, of the Observatory staff, the credit due him for the efficient time service given by these many dials.

April 1.—The Vice-President, Mr. C. A. Bigger, was in the chair. The lecture for the evening was given by Sir Frederic Stupart on the subject, "Is the Climate Changing?"

The meeting was very largely attended. A long series of cold damp days when spring should have put in an appearance had just preceded the lecture, and there many who desired an authoritative answer to the question which was the subject of the lecture.

Sir Frederic, by means of records compiled in Canada and the United States together with some records of long ago from various European countries, deduced as an answer to the question he had raised, that the climate, speaking generally, was not changing. There were long ago periods of cold summers, there were such within recent times and for all we could tell to the contrary were still to come in the future, but that the trend of the weather lay in any fixed direction he declared to be a fallacy. The deep snows of the days of the childhood of the older generation to-day were probably the result of the fact that their legs were much shorter when they trudged through it so long ago.

After the meeting an animated discussion took place on the subject and a hearty vote of thanks was tendered the lecturer.

April 27.—The President in the chair. The paper for the meeting was presented by Mr. J. L. Rannie, on "A Secondary Triangulation along the Maine and New Brunswick Boundary."

Mr. Rannie dealt with the character of the country through which the survey was run. The northern part of the line was described as rolling, but the hills were covered with hard wood forests which necessitated lines being cut for observation purposes. The southern part was more open and settled. In most cases neither cutting of lines nor erection of towers was necessary, but in all cases where some device was necessary there were towers erected as this lower part of the line is in settled country.

In all, the line is about 170 miles long. Of this, 80 miles was surveyed the first year, 1915, and the remaining 90 the next year. The average length of the lines was about 8 miles the first year and 10 miles the next. This necessitated slow observing as the lines were rather too long. Monuments were set and stations occupied which give accurately located points about every five to six miles. The error of closing of the triangles was about 3 seconds on the average. At the same time the vertical angles were read and the levels carried through. The resulting levels were very good and checked out satisfactorily at several intervening bench marks and again at the close of the line.

Mr. G. P. Conley was duly elected a member of the Society.

May 11.—The meeting was held in the Normal School. Dr. R. G. Aitken, of the Lick Observatory, was the lecturer and he chose as his subject "The Moon."

The lecturer first dealt with the movements of the moon, prefacing his remarks by stories of his experiences with the general ignorance of many people with regard to our satellite. The mechanism of eclipses was also explained, since the present year is one in which the maximum number of eclipses occurs. The details were brought out clearly by means of lantern slides.

The surface features of the moon were next discussed. This part of the lecture was particularly interesting and the many

fine slides gave added interest. The lecturer showed that the process of enlarging had a limit, for the grain of the plate finally destroyed the picture. In this respect he showed the value of good drawings by competent observers.

The absence of any air or moisture in the moon and its effect on occulations, and the experiments of photographing various materials under different colored lights and the deduction that the "rays" on the moon were, perhaps, filled up seams of different material were two other points of interest.

A discussion followed the lecture on whether the moon had any direct connection with the weather, which Dr. Aitken stated was not the case.

The ninth and last meeting of the spring term—the open air meeting—took place Saturday evening, June 2nd, at 8 p.m. The meeting was held at the Observatory. The attendance was only fair as the afternoon and early evening had been threatening. Members of the Observatory staff were on hand and a good opportunity was given of viewing the available stars and the moon. The only planet visible was Saturn.

E. A. HODGSON, *Sec.*

NOTES FROM THE METEOROLOGICAL SERVICE

Summary Report of the Weather in Canada

April, 1917

Temperature.—The temperature was below the average throughout the Dominion, except in the Yukon Territory, where it was above average, Dawson City recording the large positive departure of 6°. The chief negative departures were experienced in the Western Provinces and in the far northern portions of Ontario, and they varied between 4° and 7°.

Precipitation.—The precipitation was below the average in the Yukon Territory and locally in Manitoba, Northern Ontario, Quebec and in Nova Scotia, elsewhere over the large remainder of the Dominion, it was above the average. The positive departure was quite marked in Alberta and Saskatchewan, also in the Peninsula of Ontario and in New Brunswick. In the Western Provinces the precipitation was chiefly as snow. Occasional snowfalls were also recorded over the other Provinces. The chief positive departures in the precipitation were 4·98 inches at Vancouver, 2·00 inches at Southampton and Port Stanley, and 2·55 inches at Chatham, N.B.; while the most marked negative departures were 1·34 inches at Winnipeg, 0·93 inches at Port Arthur.

May, 1917

Temperature.—The mean temperature of May was below normal from Lake Superior eastward to the Maritime Provinces,

with negative departures averaging about 5°, but reaching as much as 8° or 9° in some parts of Northern Ontario and Western Quebec. Westward of Lake Superior to Western Saskatchewan the normal was slightly exceeded, and thence to the coast it was again in defect, and especially so in Vancouver Island.

Precipitation.—Precipitation was light and very much below the normal from Northern Ontario westward to the Pacific, except in some few sections of Central Alberta and the Interior of British Columbia. From Southern Ontario eastward it was very generally above average, but a small deficiency is reported from Quebec City.

Temperature for March, 1917

Station	April		May	
	Highest	Lowest	Highest	Lowest
Yukon				
Dawson	62	-12	74	12
British Columbia				
Atlin	54	2	72	18
Agassiz	67	30	78	35
Barkerville	46	5	67	20
Kamloops	68	19	82	33
New Westminster	68	33	72	37
Prince Rupert	66	28	72	36
Vancouver	66	35	71	39
Victoria	65	35	66	40
Western Provinces				
Battleford	50	2	93	25
Calgary	62	10	82	22
Edmonton	52	7	70	23
Medicine Hat	64	20	94	25
Minnedosa	50	6	92	21
Moose Jaw	58	10	92	21
Oakbank	53	10	86	27
Portage la Prairie	52	12	91	27
Prince Albert	52	2	84	24
Qu'Appelle	54	2	86	24
Regina	49	0	88	25
Saskatoon	48	2	90	21
Souris	55	9	93	25
Swift Current	54	6	92	20
Winnipeg	58	16	88	24
Ontario				
Agincourt	70	20	76	29
Aurora	70	18	75	28
Bancroft	65	11	75	26
Barrie	72	17	74	30
Beatrice	64	12	76	28
Bloomfield	64	19	70	32
Chapleau				
Chatham	78	23	83	32
Clinton	72	17	77	27
Collingwood				
Cottam				
Georgetown	73	17	79	32
Goderich				
Grimsby	74	22	81	32
Guelph	72	17	78	30
Haliburton	69	8	80	27
Huntsville	65	10	78	27
Kenora	52	11	86	29
Kinmount	70	13	75	26
Kingston	60	20	73	33
Kitchener	73	17	78	30
London	76	20	80	28
Lucknow	72	6	73	24
Markdale	84	9	74	27
North Gower				
Oshawa	52	24	53	32
Ottawa	62	17	80	32
Paris	76	20	81	26
Parry Sound	70	13	74	28
Peterboro'	71	17	75	31
Port Arthur	50	12	84	28
Port Dover	62	20	72	30
Port Stanley	67	18	74	30
Queensborough	68	15	74	30
Ronville	67	11	75	29
Southampton	73	18	72	26
Stonecliffe	64	16	82	31
Stony Creek	75	24	83	32
Toronto	65	20	78	34
Uxbridge	68	16	76	28
Wallaceburg	73	22	80	31
Welland	75	21	80	30
White River	54	- 7	74	12
Quebec				
Brome	62	12	79	26
Father Point	48	14	58	24
Montréal	64	18	76	32
Quebec	56	11	80	31
Sherbrooke	70	13	80	29
Maritime Provinces				
Charlottetown	58	20	60	30
Chatham	58	16	68	26
Dalhousie				
Fredericton	65	15	64	25
Halifax	68	24	66	30
Moncton	63	22	62	28
St. John	54	22	63	26
Sussex	62	20	63	25
Sydney	60	22	65	26
Yarmouth	54	22	58	28

MAGNETIC OBSERVATIONS

March and April, 1917

During the month of March no large disturbances were recorded at Agincourt or Meanook. Seven days are classified as calm, viz.: 3, 17, 19, 28, 29, 30, 31.

During April, moderately large disturbances occurred on the 6th, 9th and 16th. Five days are classified calm, 10, 11, 14, 20 and 27.

The disturbance on the 6th began with small movements during the afternoon of the 5th, with gradually increasing activity to a maximum about midnight, followed by gradually diminishing energy until the afternoon of the 6th. At Agincourt the range in D was 56′, in H 202γ and in Z 238γ. At Meanook the range in D was 1° 37′.

The disturbance on the 9th was a little longer in duration, but less active than the 6th at Agincourt. It began early on the 8th, and continued throughout the 9th. At Meanook it began gradually on the 8th, but between 1 a.m. and 6 a.m. (105th M.T.) the swings were very large and rapid. The range recorded was 4° 11′. After 6 a.m. it gradually diminished and ended during the afternoon of the 9th.

The disturbance of the 16th was very moderate at both Agincourt and Meanook. The maximum of disturbance was during the early morning hours, with small movements all day on the 15th, as well as 16th.

Not many auroræ were recorded at the Meteorological Stations during March and April. They were observed chiefly in Northern Alberta and Northern Ontario, between March 12 and 25, and from the 1st to 20th of April.

Mr. Blake reports sunspots for March and April, 1917, as follows :—During the first part of the month of March several rather large scattered groups of small penumbral spots with numerous small ones principally north of the equator, passed over the sun's surface. These reappeared again towards the last week in a more scattered condition. Those south of the

equator having disappeared. Signs of considerable disturbing action were visible in all the areas of spots. The southern parts of the northern groups were not very far from the equator. During the first days of April up to the 10th the sun was practically free of spots when again groups similar to those in March both in size and activity passed across the sun, and by the 27th most of them had disappeared around the western limb, especially those north of the equator. At the end of the month three scattered groups were visible on the sun south of the equator, the middle and largest group being just east of the central meridian.

AGINCOURT MAGNETIC OBSERVATIONS

Lat. 43° 47′ N.; Long. 79° 16′ W.

March, 1917		D. West	H	Z	I
		° ′	γ	γ	° ′
	Mean of Month	6 35·6	15960	58486	74 44·2
	Maximum	6 53·7	16004	58514	
	Date of Maximum	5	20	8	
	Minimum	6 04·3	15839	58447	
	Date of Minimum	20	25	5	
	Monthly Range	49·4	165	67	
Mean Daily Amplitude	From hourly readings	14·1	60	8	
	From means of extremes	19·3	119	20	

April, 1917		D. West	H	Z	I
		° ′	γ	γ	° ′
	Mean of Month	6 35·8	15960	58462	74 43·8
	Maximum	7 01·3	16048	58528	
	Date of Maximum	9	30	5	
	Minimum	6 06·4	15747	58290	
	Date of Minimum	5	9	6	
	Monthly Range	54·9	301	238	
Mean Daily Amplitude	From hourly readings	13·0	50	15	
	From means of extremes	22·2	89	50	

H and Z are given in Gammas. (1 γ = 0·00001 C.G.S.).

All results are reduced to I.M.S.

MEANOOK MAGNETIC OBSERVATIONS

Lat. 54° 37′ N.; Long. 113° 21′ W.

March, 1917		D. East	I
		° ′	° ′
	Mean of Month	27 45·9	77 54·9
	Maximum	28 47·3	
	Date	13	
	Minimum	27 03·5	
	Date	5	
	Monthly Range	1 43·9	
Mean Daily Amplitude	From hourly readings	11·9	
	From means of extremes	30·8	

April, 1917		D. East	I
		° ′	° ′
	Mean of Month	27 45·9	77 55·5
	Maximum	29 55·9	
	Date of Maximum	9	
	Minimum	25 45·0	
	Date of Minimum	9	
	Monthly Range	4 10·9	
Mean Daily Amplitude	From hourly readings	15·7	
	From means of extremes	42·9	

The value for I is the mean of all the observations made during the month without regard to the time of day.

All results are reduced to International Magnetic Standard.

W. E. W. J.

Earthquake Records by the Milne Seismograph

TORONTO

Sir Frederic Stupart, Director.

P.T. = Preliminary Tremors. S. = Secondary Waves. L.W. = Large Waves. A.C. = Air Currents. Time is Greenwich Civil Mean Time, 0 or 24 h = midnight.

No.	Date 1917	P. T. Comm.	S. Comm.	L.W. Comm.	Max.	End	Max. Amp.	Remarks
		h m	h m	h m	h m	h m	mm.	
1694	Apr. 3			14 14·1	14 17·3		0·2	
1695	" 12			4 03·5		4 07·0	0·05	
1696	" 21			0 46·3?) 1 07·2)		1 43·0	0·1	Micros. going on.
1697	" 23			1 24·3?		1 47·7	0·05	
1698	" 28			16 17·6		16 19·9	0·05	
1699	" 29			12 38·3	12 42·9 19 31·8	13 23·0?	0·3	
1700	May 1	18 42·1	18 53·4	19 03·1	to 19 37·3	0 51·9	over 27	Large disturbance, well defined.
1701	" 2			2 21·6	2 27·9	3 13·2	0·4	
1702	" 2			3 31·9?	4 12·4	5 06·4	0·4	May be part of quake No. 1701.
1703	" 2			5 15·4?) 5 26·5)	5 29·3	7 19·2?	0·3	
1704	" 2			8 14·3		8 18·0	0·05	
1705	" 2			15 02·1	15 17·4	15 30·6	0·3	
1706	" 3			13 01·6) 13 05·0)	13 06·3	13 30·4	0·2	Marked double maximum.
1707	" 4	1 35·9?		1 44·3	1 50·1	3 35·1	0·7	
1708	" 6, 7			23 52·0	0 06·8	0 42·0	0·3	
1709	" 7			9 19·1?		9 24·5	0·05	lance.
1710	" 9		16 26·5?	16 41·1	17 06·0	18 53·8	1·6	Marked disturb-
1711	" 9			20 34·0	20 37·5	A. C.	0·8	Possibly a dual
1712	" 14			22 35·3?		A. C.		earthquake.
1713	" 24			20 25·1	20 27·7	20 50·3?	0·2	
1714	" 25			14 58·5	15 01·2	15 05·2	0·1	
1715	" 29			6 59·8	7 12·5	7 48·2	0·9	Marked gradual increasing and decreasing thickening.
1716	" 31	8 56·5	9 03·7	9 13·1	9 21·5	12 29·2	4·0	5,550 km. marked record —Alaska.
1717	" 31			19 53·6			0·05	

Period of boom 18 seconds. Pillar inclination 1mm. = 0″·50.

VICTORIA, B. C.

F. N. DENISON, SUPERINTENDENT.

No.	Date 1917	P.T. Comm.	S. Comm.	L.W. Comm.	Max.	End	Max. Amp.	Remarks
		h m s	h m s	h m s	h m s	h m s	mm	
1714	Apr. 3	13 48 30?		13 55 26?	14 05 21	14 24 41	0·3	
1715	" 12				3 58 03		0·1	
1716	" 23	1 00 30?			1 21 49		0·2	
1717	" 28			16 16 06 } 16 16 48 }			0·05	
1718	" 29	12 30 34?	12 32 34?	12 34 33	12 38 31	12 49 55	0·5	
1719	May 1	18 31·5	18 39·5	18 49·9	19 15.0 to 19 18·2	23 35·0	17 and over	6,370 km. Kamchatka
1720	" 2	1 51·4?			2 10·7	2 31·5	0·5	Prob. after shock of above
1721	" 2			3 41·5	at cut-off	4 04·7	?	" "
1722	" 2				5 12·2		0·2	" "
1723	" 2			14 54·9?	15 02·8		0·1	" "
1724	" 3				13 18·2	13 22·5	0·4	
1725	" 4	1 06·8?			1 41·5	2 28·6	0·7	
1726	" 6	23 33·5?			23 44·4	23 58·8	0·6	
1727	" 7	8 58·8?			9 02·3	9 04·7	0·1	
1728	" 9	15 59·8	16 07·8	16 17·5	16 44·5	?	3·5	5,370 km. May be Kamchatka.
1729	" 9				21 30·6		0·2	May be part of
1730	" 14	22 42·0?		22 44·5	22 52·4	23 16·7	0·2	above.
1731	" 24	20 03·0?		20 10·5?	20 12·0	?	0·2	
1732	" 25	14 52·0		14 53·5	14 55·0	15 01·0?	0·2	
1733	" 29	6 44·6?		6 47·0	6 52·0	7 02·8	0·5	
1734	" 31	8 53·9	8 57·7	8 58·4	9 01·3	12 25·6	14·5	2,290 km. Alaska Peninsula. S. waves large amp.
1735	" 31			19 53·7		19 59·0?	0·1	Minute vibs. well marked.

Boom period 18 seconds. Pillar inclination 1mm. = 0″·54

VERTICAL COMPONENT

Date 1917	P.T. Comm.	S. Comm.	L.W. Comm.	Max.	End	Max. Amp.	Remarks
	h m	h m	h m	h m	h m	μ	
May 1	18 32·0	18 40·3	18 50·0?	?	?	200	6820 km.
" 9	15 59·0	16 06·0	?	16 39·5		167	5320 km.
" 31	8 53·9	8 56·8	8 58·2	9 01·0		67	1680 km.

The measurements for Victoria during May are in tenths of a minute.

J. Y.

ASTRONOMICAL NOTES

ADDRESS OF SIR JOSEPH THOMSON—A MEMORIAL TO SIR WILLIAM AND LADY HUGGINS.—There can be no question as to the claim of Sir William Huggins, the founder of astrophysics, as he has been called, to such a memorial, nor any doubt as to where it could most appropriately be placed. For no man of equal scientific eminence was ever more closely connected with this city. He was born in London, he was educated entirely in London, he was in business in London, and when he retired from business to devote himself to astronomy he built his observatory in London; and in spite of the fact that the atmosphere of London is far from being an astronomer's ideal, all the observations which led to the discoveries on which his fame rests were made in London. This great Cathedral seems the appropriate resting-place of a memorial to one whose life and work were so linked up with this city.

Sir William Huggins was a prominent example of a type of man to whom English science owes much, the non-official worker. Like his contemporaries, Darwin and Joule, he never held any professorship or scientific appointment. When in 1858 he retired from business at an unusually early age, he seems to have been undecided as to whether he should devote himself to the microscope or the telescope. The telescope gained the day, and he built an observatory at Tulse Hill; he began by making drawings of the planets, but seemed to be losing interest and to be rather despondent, when Kirchoff's determination of the chemical elements in the sun by the aid of spectrum analysis

came to his knowledge. This was to him, he says, like water in a thirsty land, and he determined to attempt to find out the constitution of the stars by the same method. At the beginning of 1862 he persuaded Professor Miller to join with him in the work, and in spite of the formidable difficulties due to the feebleness of the light, the mechanical difficulties of keeping the image of the star on the slit of the spectroscope, and the caprice of the London atmosphere, they were able to present to the Royal Society, in 1863, a preliminary statement as to the spectra of some of the brighter stars, while in 1864 they published in the *Philosophical Transactions* of the Royal Society a general account of the spectra of about 50 stars, with a detailed study of some of the more important ones. They showed that the stars are made up of elements which, with few exceptions, are found in the earth. In 1864, Huggins made a discovery of capital importance in connection with the evolution of the stars, for he discovered a nebula the spectrum of which showed that it consisted of glowing gas, and was, therefore, in quite a different state of development from the stars he had examined, the spectra of which showed that their physical condition was analogous to that of the sun. Huggins threw himself with characteristic energy into the study of the spectra of the nebulæ, and found that the nebulæ were not all of one kind; some were stellar aggregates, while others were continuous masses of incandescent gases.

The importance of these results and the interest they excited were recognized by scientific societies with a promptitude almost without parallel. Three years after beginning serious scientific work he was elected a fellow of the Royal Society, the next year he was awarded a Royal medal, and after ten years he seems to have been elected to almost every scientific society in Europe. The work which commenced with such brilliance was carried on with undiminished ardour for nearly fifty years; since 1875 with the active co-operation of his wife. It showed throughout the characteristics so noticeable in the earlier work: the power to select the right problem to attack, the ability to devise the best way to attack it, and the industry to take boundless pains in

overcoming the difficulties which sprang up at every turn.—*Nature*, April 19.

NOTES, ROYAL ASTRONOMICAL SOCIETY.— Some interest was shown at last Friday's meeting of the Royal Astronomical Society at Burlington House in a present, just received, of facsimiles of parts of the original letters in which the great French astronomer, De Lalande, insisted on associating Herschel's newly discovered planet, now known as Uranus, with the name of the discoverer by means of the symbol adopted to denote the new planet, representing Herschel's initial with a small planet suspended from the bar. The Society also welcomed a visit from Professor Lecointe, Director of the National Observatory, of Brussels, who appeared in khaki. Professor Eddington gave some further notes on the radiative equilibrium of the stars, having arrived at the conclusion that the total radiation depends only on the mass, and so does not vary with successive stages of evolution. He gave details in support of his conclusions, from which, however, Mr. Jeans, who is studying the same problem from a more physical point of view, differed very definitely. The next step of either of these investigators is awaited with great interest.—*English Mechanic and World of Science*, June, 15.

ROTATING MASSES.—To sum up, it appears fairly certain that the rotational process can account for the formation of binary and multiple star-systems. There is, at least, a chance that it can account for spiral, and possibly also ring, nebulæ; and there is very little chance left that it can account for the solar system.

It is natural to enquire where the nebular hypothesis stands in the light of recent theory and observation, and it appears that this hypothesis can be modified so as to present a not unreasonable, although still largely speculative, view of cosmic evolution. Conjecturally, we may imagine an irregular mass of gas falling together under its own gravitation and acquiring rotation, possibly through the tidal action of other masses moving past it. As its density increases, it assumes first a flattened shape like a planet-

ary nebula, then a lens-shape like that of Roche, and, finally, the spiral form. If the mass is on a sufficiently great scale, the ejected matter condenses into streams of stars—we have first a formation like the Andromeda nebula, later a flat galaxy of stars, rotating and moving in one plane. After subsequent interactions the stars no longer move in the plane in which they originated, and the star-cluster becomes first spheroidal and then, perhaps, almost globular. Meanwhile, the constituent stars are themselves condensing further and breaking up—first into binary and later into multiple systems. Such a scheme, although far from being necessitated by either theory or observation, is not contradicted by either, and seems fairly plausible. But it does not explain the genesis of our solar system, which is what the original nebular hypothesis set out to do; to trace the origin of this we must apparently look to agencies other than rotation.—J. H. JEANS, in *The Observatory*, No. 513.

THE TEMPERATURE OF SPACE—SUMMARY—If we attempt to define precisely the temperature at a point of space by the introduction of a *testing body*, we find that the temperature of that body may vary enormously according to its absorptive properties.

A testing body with a *black* surface does not have any special interest from the theoretical point of view, but a body with selective absorption may take a temperature much lower or *much higher* than that of the black body.

When the absorption is limited to the short wave-lengths, a feeble radiation may develop a very elevated temperature.

It is not impossible that this last case occurs for gaseous masses, which would then have the property of emitting, under the influence of the incident radiation, the same radiations which they absorb.

One may thus attempt in a very hypothetical manner an explanation of the emission spectrum of comets by this process. —CH. FABRY, in *Astrophysical Journal*, May, 1917.

J. R. C.

NOTES AND QUERIES

Communications are Invited, Especially from Amateurs. The Editor will try to Secure Answers to Queries.

NEW MOON IN JANUARY, 1 B.C.

Dr. Otto Klotz, of the Dominion Observatory, Ottawa, sends the following note :—

In making some computations last March about the occurrence of New Moon, an error of statement was discovered in the 9th edition of the *Encyclopædia Britannica* under "Calendar" Vol. IV., p. 594, and repeated in the 11th edition, Vol. IV., p. 993 ; it is also given in Barlow & Bryan's "Mathematical Astronomy," p. 215. The erroneous statement is that New Moon occurred on January 1, in 1 B.C. New Moon in January, 1 B.C., occurred on January 25, $12^h\,26^m$, Jerusalem Civil Time.

AN AURORAL DISPLAY, BEGINNING IN THE SOUTH

Mr. A. F. Hunter, M.A., contributes the following :—

At 10 p.m. on June 12, while members of this Society were assembled on the University campus with telescopes viewing the stars, a slight auroral display added to the interest of the occasion. While this display was of minor extent and short duration, it had some rare features that were noteworthy. It began in the south-west,—the opposite quarter to that in which displays usually begin. There were no upright streamers such as those with which everyone is familiar, but instead of them there were faint horizontal bands of light changing their forms and places with the same rate of speed as that of the ordinary upright streamers. Associated with these, there was a feeble rose tint in the same parts of the sky. The changing bands of light issued from the

position occupied by the sun below the horizon. The display took place at the time of the daily midsummer maximum of the aurora, *viz.*, at 10 p.m. and lasted only about 20 minutes. Toward its close a few bands of the same kind appeared overhead and in the northeast, where it seemed to end with a faint glow. Simultaneously, the receiver of the wireless station yielded more crackling sounds than usual, and an electric storm occurred on the following evening.

ART AND ASTRONOMY IN HAMILTON

We are much pleased to learn of the activity of Mr. William Bruce, J.P., Honorary President of the Hamilton Centre of the R.A.S.C., who though well past four-score years of age, is busily engaged in astronomical, artistic and philanthropic work. On the evening of May 30, last, he gave a unique entertainment for the benefit of one of the churches on the Mountain, near his home. It consisted of, first, "an imaginary aerial trip to Mount Tycho, the most sublime portion of the moon's scenery;" and, second, a talk on "Art," illustrated with a series of original, colored tableaux lantern slides, designed and made by Mr. Bruce, and never shown before. As some of his neighbors had posed for many of these slides there was great local interest.

Mr. Bruce also keeps a continuous "open house" at his observatory, and welcomes all visitors interested in astronomy.

COMETS IN THE SKY

There are several comets in the sky at the present time, but none of them very interesting to the amateur.

Elements and an ephemeris for Mellish's Comet were given in our last issue. The object is diminishing in brightness.

On April 25 a comet was discovered by Schaumasse, at Nice, in R.A. $23^h\ 5^m\ 44^s$, Decl. $+\ 10°\ 19'$ (in Pegasus). Its magnitude at the time was 9·5 and it continued for some time to be visible in a small telescope. From observations on April 28, and May 6 and 17, the following elements and ephemeris were computed at

the Students' Observatory, Berkeley, Cal., by Mr. Jeffers and Miss Young :—

ELEMENTS

Time of perihelion passage	(T)	1917, May 18·23	G.M.T.
Perihelion minus node	(ω)	119° 04′	
Longitude of node	(Ω)	9° 32′	
Inclination	(i)	158° 44′	
Perihelion distance	(q)	0·764	

EPHEMERIS

G.M.T.		R.A. h	m	s	Decl. °	′	Light
1917, May	30·5	8	14	5	+14	11	6·24
June	3·5	8	50	10	+31	50	
	7·5	9	8	11	+25	40	
	11·5	9	18	38	+21	28	1·40
	13·5	9	22	21	+19	51	1·14

Wolf's Comet, discovered in April, 1916, but coming to perihelion in June, 1917, was at first thought likely to become a prominent object this summer in Pegasus. But it has proved a disappointment, its brightness being much below what was expected. Pettit, of Topeka, Kansas, states that on April 30 the comet had a tail 6′ long and a fairly well defined nucleus. Lick Observatory *Bulletin*, No. 295, contains elements and ephemeris, computed by Crawford and Alter, from which the following is taken :—

ELEMENTS OF COMET *b*1916 (WOLF)

T = 1917, June 16·5373 G.M.T.
ω = 120° 36′ 01″·2
Ω = 183 17 50·4 } 1917·0
i = 25 40 10·8 }
log q = 0·227067

EPHEMERIS

G.M.T.		True α h	m	s	True δ °	′	″	Brightness
1917, June	2·5	21	49	31·4	20	42	42	1·84
	10·5	22	07	12·1	22	13	15	2.00
	18·5		23	57·7	23	24	46	2·15
	26·5		39	33·3	24	14	03	2·29
July	4·5		53	45·1		38	16	2·42
	12·5	23	06	19·4		34	58	2·53
	20·5		17	01·2	24	01	30	2·61
	28·5		25	40·9	22	55	39	2·67
Aug.	1·5		29	13·5		10	13	2·68

The comet will be in a favorable position for observing all summer, becoming brightest in the first week of August.

C. A. C.

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA
Officers for 1917

Honorary President—J. S. PLASKETT, B.A., D.Sc., Ottawa
President—ALBERT D. WATSON, M.D.
First Vice-President—ALLAN F. MILLER.
Second Vice-President—WM. BRUCE, J.P.
Secretary—J. R. COLLINS. *Treasurer*—CHAS. P. SPARLING.
Recorder—W. E. W. JACKSON, M.A. *Librarian*—PROFESSOR C. A. CHANT.
Curator—ROBERT S. DUNCAN.

Council—The above Officers, and the following members:—Rev. I. J. KAVANAGH, M.A., D.Sc., S.J., Montreal; OTTO KLOTZ, LL.D., D.Sc., F.R.A.S., F.R.A.S.C., Ottawa; Rev. Dr. MARSH, F.R.A.S., Holstein; Sir JOSEPH POPE, K.C.M.G., Ottawa; STUART STRATHY, Toronto; Dr. W. M. WUNDER, Toronto; and Past Presidents ANDREW ELVINS, JOHN A. PATERSON, K.C., M.A.; SIR FREDERIC STUPART, F.R.S.C.: Professor A. T. DELURY, Professor LOUIS B. STEWART; and the presiding officer of each Centre as follows: J. J. MCARTHUR; W. A. LOGAN, C.E.; J. M. WILLIAMS; JAMES DUFF, M.A.; E. POWELL; H. J. B. LEADLAY, and A. W. MCCURDY.

OTTAWA CENTRE

President—J. J. MCARTHUR. *Vice-President*—C. A. BIGGER.
Secretary—E. A. HODGSON. *Treasurer*—D. B. NUGENT.
Council—DR. W. BELL DAWSON, G. B. DODGE, THOS. FAWCETT.

PETERBOROUGH CENTRE

Local President—W. A. LOGAN, C.E. *Vice-President*—T. A. S. HAY.
Secretary-Treasurer—T. C. ELLIOT.
Council—H. O. FISK, C.E.; DUNCAN WALKER, B.A.; D. E. EASSON, B.A.Sc.; HENRY CARVETH.

HAMILTON CENTRE

Honorary President—WM. BRUCE, J.P.
Local President—J. M. WILLIAMS. *Vice-President*—W. A. ROBINSON.
Secretary—T. H. WINGHAM, B.A. Sc. *Treasurer*—SENECA JONES.
Council—J. J. EVEL, REV. J. J. MORTON, MISS I. M. WALKER.

REGINA CENTRE

Hon. President—DR. W. W. ANDREWS.
Hon. Vice-President—N. MACMURCHY, B.A.
President—JAS. DUFF, M.A. *Vice-President*—Mr. TRELEAVEN, B.A.
Secretary-Treasurer—W. G. SCRIMGEOUR, M.A.
Auditor—J. E. CAMPBELL, B.A.
Council—T. H. BISSONNETTE, B.A.; E. R. MURRAY, H. S. MACCLUNG, B.A.; Miss E. D. CATHRO, B.A.

WINNIPEG CENTRE

President—F. POWELL. *Vice-President*—J. H. KOLB.
Secretary-Treasurer—DR. J. W. CAMPBELL.
Council—C. E. BASTIN, B.A.; REV. FATHER J. BLAIN, S.J.; J. W. HARRIS, MRS. HOWEY, H. R. KINGSTON, M.A., Ph.D.; PROF. L. A. H. WARREN, M.A., PH.D., F.R.A.S.

GUELPH CENTRE

Honorary President—JAMES DAVISON, B.A.
President—H. J. B. LEADLAY.
1st Vice-President—R. R. GRAHAM, B.A.Sc.
2nd Vice-President—LT.-COLONEL D. MCCRAE.
Secretary-Treasurer—J. MCNIECE, B.A. *Recorder*—R. F. BENNETT, M.A.
Council—MRS. J. J. DREW, MISS MARY MILLS, F. A. GRAESSER, PROF. W. H. DAY, M.A.; H. WESTOBY, J. M. TAYLOR, Sr.; J. W. CHARLESWORTH, W. LAIDLAW and COL. A. H. MACDONALD.

VICTORIA CENTRE

Honorary President—DR. J. S. PLASKETT, B.A., D.Sc., Ottawa.
President—A. W. MCCURDY. *Vice-President*—W. S. DREWRY, C.E.
Secretary—G. S. MCTAVISH. *Treasurer*—J. P. HIBBEN.
Auditor—JAMES FORMAN.
Council—THOMAS SHOTBOLT, F. NAPIER DENISON, K. M. CHADWICK, J. T. SHENTON, J. UMBACH, F. C. GREEN, and A. SYMONDS.